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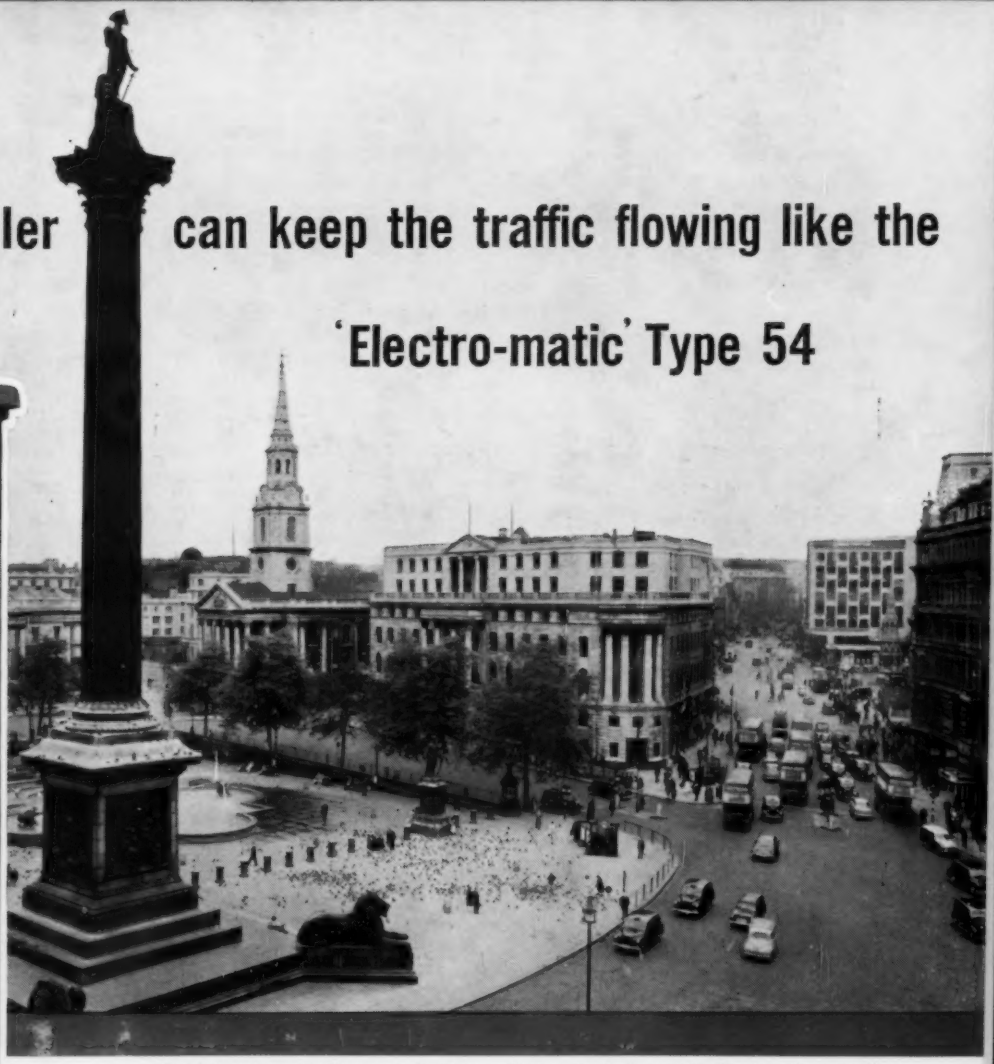

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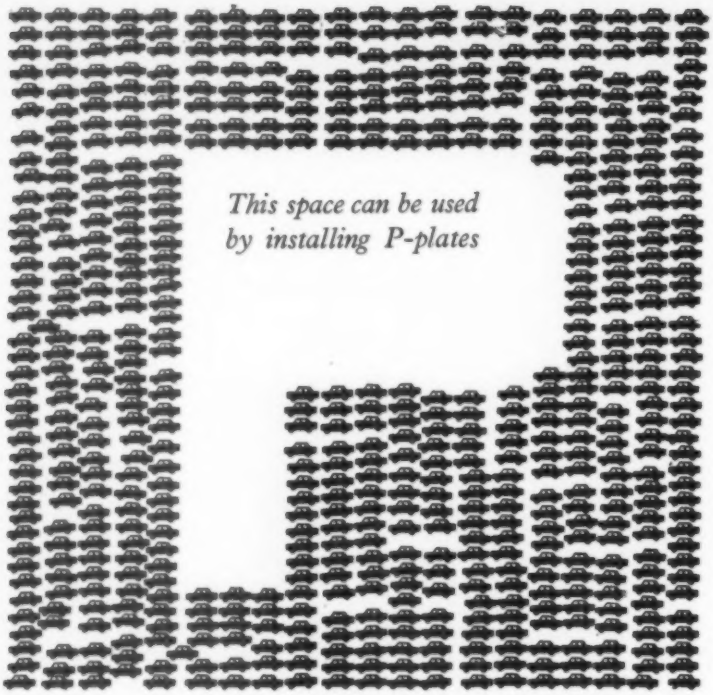

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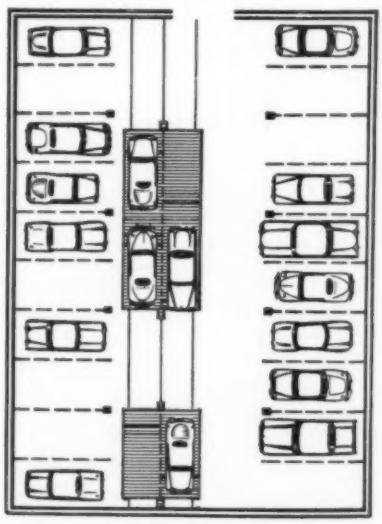

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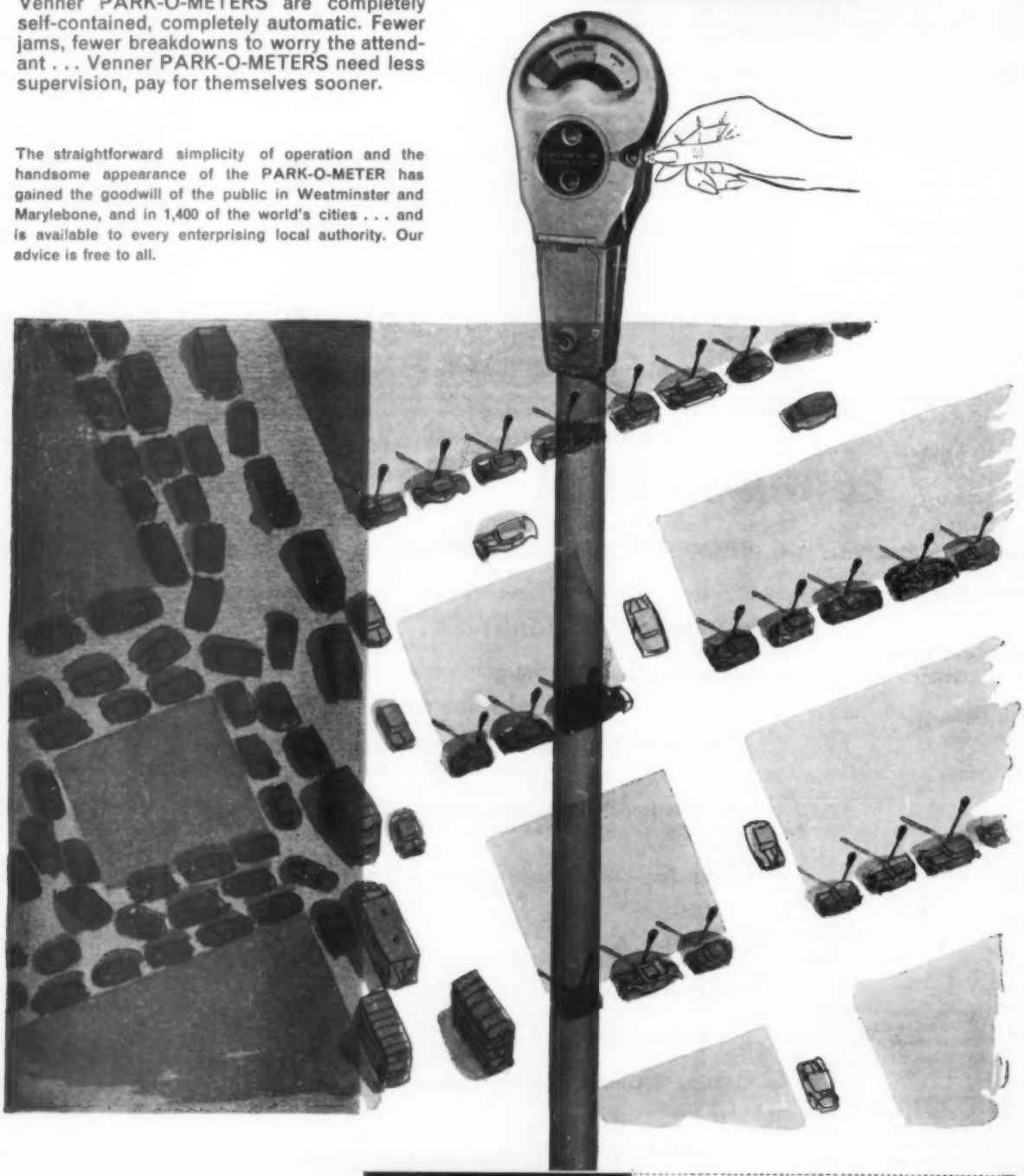

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Problems for Nice

THE Fifth International Study Week in Traffic Engineering assembles at Nice at a time when the importance of the subject of its deliberations is being increasingly appreciated and more widely practised in a growing number of countries. But those responsible for the development of the methods and techniques of this science of traffic are faced with a hard fight to keep pace with the growing demands made upon them by the undiminishing growth in motorization. The matters down for discussion at this international conference indicate the wide field and the important problems now covered by traffic engineering, stretching as they do not only from the problem of capacity to intersection design, and from traffic and parking needs to visual aids, but also to economic, social and transport policies. Thus also to be considered are traffic needs generated by building development, economic losses due to traffic congestion, and the conflict between individual and public transport. The significance of this choice of subjects is that it reflects recent development in traffic engineering and an extension of its boundaries.

Concerned as it was in its early days in the United States with traffic operations, when first recognized as a specialized field, traffic engineering now extends its previous limited sphere of geometric design and traffic regulation and control to the wider area of transport policy and roads and traffic planning. This evolution follows naturally on not only the greater complexity of the problems with which the traffic engineer has to deal, but also on the growing realization that roads and traffic problems can no longer be dealt with independently of town and country planning, of development schemes, of land use and urban renewal. The traffic engineer is no longer solely concerned with palliatives for alleviating congestion arising from the inadequate capacity of an obsolete roads system, but equally with assisting in the planning of cities and in finding how best to live with the motor car. The modern traffic engineer thus finds himself working as closely with the town planner and architect as did his predecessor with the local police.

It accordingly rests with this team of planners, designers and engineers to face the challenge thrown up by the increasing grip that motorization is getting on urban areas. If he fails to do so, the economic and social life of the community may in the end suffer as much from the advent of the motor era as it has gained from it. The main requirement is to find the means to ensure orderly development since the major problems that have to be solved concern the future of our cities on the one hand, and, closely related to it, of public transport on the other. The main conflicts are between urban spread and the planning of land use, and of public versus private transport. The exchange of experience at Nice should enable the European countries which, by and large, in regard to their roads programme and the extent of motorization, have lagged behind America, but are now closing the gap, to gain from its experience. Across the Atlantic, the tremendous programme of interstate highways and urban expressways has not only generated a great volume of traffic for which the cities are struggling to provide, but it has led to an extension of many a city's catchment area far beyond its original limits. This urban spread has resulted in some diminution of the importance of the city as the centre of social and economic life at the same time as traffic congestion has greatly increased and slowed down public transport, reduced its appeal as a means of travel and rendered it uneconomic. The necessity to provide land for the ever-widening expressways and their intersections that cater for the daily influx, and storage space for the vehicles that bring it in, can destroy the character of the city and render it less attractive for social and community life, for shopping and entertainment. It is to prevent this process from going so far that the city is reduced to a mere place of work that calls for the urgent attention of the planners and the engineers.

The contribution that the traffic engineer can make to the solution of this problem is considerable. In the first place, he can collect and analyse traffic data and assess the traffic demand and predict its future development, and, in the second place, on the basis of this predicted need, he can help in the planning of the roads and traffic network so that the needs are met without the destruction of the city as a centre of community life. This requires a balance to be held between the provision of expressways and of public transport facilities, it requires the raising of the potential capacity of existing streets by the full use of modern traffic engineering methods to aid traffic flow, with full regard paid to the necessity of keeping public transport moving, especially at peak periods.

While these major problems of policy and planning have now become the subject of concern to the traffic engineer as well as the town planner, and will be discussed at Nice, there are a number of more technical problems of immediate concern that will occupy him there also. Delegates to the Conference will, therefore, in no way be short of topics for discussion, nor will those who are to attend the International Road Safety Congress which follows immediately on it, and which is to discuss the vitally important problem of road accidents.

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Topics of the Month...

Tickets and Traffic Wardens

THE Road Traffic and Roads Improvement Act (1960) which came into force on September 1. Despite fears expressed during its passage through Parliament that its two main provisions, the employment by the police of traffic wardens, and the use of the ticket system with fixed fines for parking offences, would encroach upon the traditional process of law, they are now to be tried out in London and if they prove successful, subject to Parliament's further approval, elsewhere. The Home Secretary wisely anticipated the Act's coming into force and authorized the Metropolitan Police to enrol traffic wardens in advance. The effectiveness of this supplementation of enforcement by these measures depends on the tactfulness with which the new powers are used and the co-operation of the public. Initially, only a small force of wardens is to be employed, and its duties strictly limited to dealing with minor offences, mainly in connection with parking meter schemes; and a rather unnecessary undertaking was forced from the Government spokesman in the House of Lords that these powers would not be used in cases of obstruction. If the system proves effective in persuading motorists to respect the parking regulations, it should be possible to extend it to other minor motoring offences and to cities outside the Metropolis, where the need for stricter enforcement is just as great.

The success of the new experiment depends, however, upon the speed with which use is made of the other provisions of the Act designed to accelerate the institution of parking schemes to meet the needs of short and long-term parkers alike. Enforcement of regulations by neither wardens nor police can be fully effective as long as there is inadequate provision for off-street parking. Without it, the motorist's co-operation is unlikely to be forthcoming. It is here that the parking meter schemes have so far failed to fulfil their purpose, and it is to be hoped that the extended powers given to the local authorities, including the greater facility with which they are to be permitted to construct, operate and lease multi-storey garages, will be fully and speedily employed.

Increased Roads Expenditure

THE higher allocation to the roads programme announced by the Minister of Transport is gratifying, especially in view of the Government's intended reduction in public expenditure elsewhere, and is a measure of its realization that an obsolete roads system is a brake on economic expansion. But the increase in the State's contribution for England and Wales from £65 million this year to £75 million next year, and to £88 million the year after, is small when set against the expenditure on, for instance, defence, or in comparison to the known need, or, for that matter, to expenditure by other countries of Western Europe. In view of the proved availabilities of equipment and materials, let alone plans with which the pigeonholes of the Highway Authorities are stuffed, it is difficult to believe that this is the maximum that the country can afford at this time. The increased allocations will, however, enable the five major projects for through routes, mainly motorways, to be accelerated, but unless the building of urban motorways or adequate roads leading into the centres of the cities they are to connect, is to run concurrently with their construction, the full economic benefits will not be obtained. Some satisfaction can, however, be gained from the fact that Mr. Marples was able to announce that the grant to the authorities responsible for classified roads is not only te be nearly doubled, but is to be determined on a five-year basis which will enable longer term planning than was possible with the uncertainty that inevitably accompanied the annual grant.

Chance for Traffic Engineering

NOW that the responsible authorities can look further ahead, they have the opportunity of deciding on priorities based on a better assessment of future needs than has in the past too frequently been the case. The need for quick decision to obtain Ministerial authorizations has sometimes led to acting on hunch and to construction on the basis of plans drawn before modern techniques of traffic engineering and current ideas on geometric design were available to be called in aid. All major cities should now, therefore, be encouraged by the Ministry to undertake traffic studies before major projects are undertaken and to revise their plans in accordance with them. Few have yet done so, nor have they the necessary staff available for the work, since, because of the inadequacy of training facilities, there is an acute shortage of traffic engineers in this country. One way out would be the employment of outside consultants which would have the added advantage of making better known the technical know-how of those countries more advanced in this field. In this connection, it is significant that both American and Canadian firms of traffic engineering consultants are known to be establishing offices here, or are exploring the possibility of doing so.

The Minister announced some time ago that a survey was to be made for Greater London, and work on it should start soon. In view of the increased expenditure on classified roads, of which London it is hoped will have its proportionate share, the need for speedy conduct of the survey assumes added urgency and, here again, it would appear that because of the lack of trained personnel and experience outside consultants might be employed to advantage to organize and supervise the survey with, of course, the maximum number of local personnel employed to gain the knowledge and experience. There need be no sensitivity on nationalistic grounds on this score, because if there is a shortage of staff, it is almost entirely due to the absence of a roads construction programme until comparatively recently.

TRAFFIC CONTROL DEVICES

Philadelphia's ELECTRONIC CONTROLLED Signal System

by Richard Overmyer, Traffic Engineer

Fig. 1. Typical business street, Centre City Philadelphia.

TRAFFIC problems in all American cities have been growing at an alarming rate, particularly since 1946, following the end of World War II. During the war years in the United States, passenger vehicles were out of manufacture and the quantities of motor vehicles in use gradually decreased during these years. However, since the end of World War II, new vehicles have been manufactured in abundance and the growth of traffic volumes has been tremendous ever since.

In the City of Philadelphia, an old eastern seaport city, the traffic problem has become tremendously acute because of the inflexibility of the street system. Western cities which are now enjoying very rapid population growth are being planned and built with the automobile in mind. Eastern cities, such as Philadelphia, are not experiencing this same rate of population growth and have a stabilized community with a street system which was developed before the motor car became a part of community life. This problem which is common to all eastern cities is evidenced most clearly in the City of Philadelphia.

Philadelphia has a population within the city limits of approximately 2,000,000 people, and is the centre of a metropolitan area containing approximately another 1,750,000 persons. The business heart of this large metropolitan area is a very limited area (1.8 sq. m.) called 'Centre City Philadelphia', bounded on the east and west by rivers and on the north and south by historical boundary lines separating the centre core area from the neighbouring light industrial, commercial and residential areas. (*See fig.* 1). Centre City is about 340 blocks in area and contains the major shopping, financial and business institutions, as well as the major hotels. Within the Centre City area, most streets have 26-foot carriageways and nearly all streets are one-way. The 26-foot streets not only must provide for moving traffic but also to a very marked degree provide access for commercial vehicles to the commercial and industrial establishments in the area. Each day slightly less than one million vehicles pass across the cordon-line surrounding the Centre City area. Obviously, not all the vehicles have origins or destinations in the area, but because of physical conditions large volumes of traffic must use the Centre City streets in moving between areas. The million vehicles enter or leave the central city area daily, despite the fact that nearly 70 per cent of all people entering the central business district travel by public transport facilities. Philadelphia is fortunate in having within the Centre City area four subway lines which provide high speed public transport, as well as various railway commuter lines and good surface public transport. Nevertheless, there continues to be a trend of growth in use of private cars for commuting and for business as it pertains to the central city area.

The traffic problem had increased in 1955 by such a marked degree that a complete re-appraisal of traffic conditions in the Centre City area was dictated. This re-appraisal involved careful study of traffic volumes and trends, patterns and hours of travel, public transport facilities, and considered consolidation of lines, as well as a general review of parking and one-way regulations. The study further involved a complete speed and delay study throughout the entire Centre City area, in an effort to pinpoint as much as possible the amount of delays and the causes, as well as normal operating and running

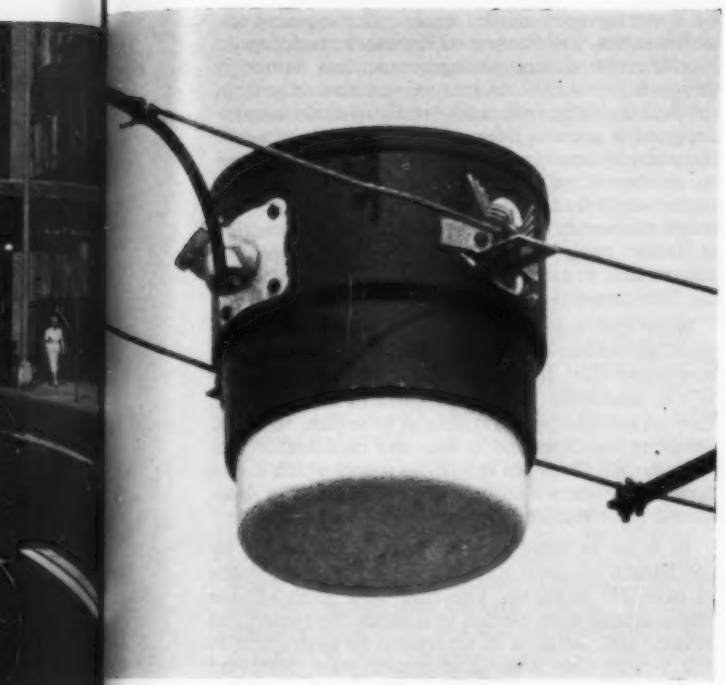


Fig. 2. Radar traffic detector above street.

speeds. Analysis of these studies indicated that the operating speeds in the central city area varied from a low of 7 m.p.h. to a high of 16 m.p.h., with most traffic lying in the range of 9 to 13 m.p.h. Further analysis of the speed and delay data indicated that, during mid-day hours, 70 per cent of the stops and 87 per cent of the delay were caused by the 320 traffic signals then in operation. The same facts held basically true during the peak hours, as well, and it was concluded that other than reconstruction of the street system, best gains in traffic movement within the Centre City area would be accomplished by the design and construction of a new modern traffic signal system.

When it was decided that a new signal system was required, careful study was made of the existing equipment and facilities to determine the extent that existing equipment could be utilized. At that time the traffic signal equipment in the Centre City area included 12 separate interconnected fixed-time systems, none of which was related to any other, plus approximately 50 isolated fixed-time signalized intersections. It was obvious that to achieve continuity of movement, both north and south and east and west, the 50 isolated intersections would have to be added to the interconnected system. The development of an interconnection plan constituted Phase 1.

Phase 2 of the project was the determination of the objectives of the new system, some of which were:

(a) Progressive traffic movement on as many streets as possible.

(b) Operating speeds above those which presently existed, with the optimum being the range of 15 to 20 miles per hour.

(c) Adequate pedestrian times for street crossings.

(d) Complete flexibility of the system so as adequately to control varying traffic volumes and preferential directions.

From these goals, preliminary design criteria were developed to be used in assessing the applicability of signal equipment available at the time.

When these studies were being conducted, and design criteria were being established for a new traffic signal system, signal equipment then available was limited to fixed-time three-dial controllers with three offsets; one for inbound, one for outbound and one for normal bi-directional flow, which could be interconnected, and which could be controlled by a master controller operated by a weekly programmed timer. This system, of course, was adaptable to adjustments manually when the need was indicated. However, to meet the needs in the Centre City area of Philadelphia, it was obvious to the staff traffic engineers that our goals would not be reached with the fixed-time equipment being marketed. More flexible electronic equipment was necessary.

The only electronic signal equipment then on the market were controllers designed to handle isolated independent intersections, and an electronic system which had been developed for use along arterial-type streets called a cycle-selector system. In Philadelphia, considerable experience had been obtained with the latter type of equipment, since in 1954, Broad Street, the major north-south arterial street in the city, had been converted from fixed-time traffic signal control to this type of electronic equipment. In the four years following the installation of the cycle-selector systems on Broad Street, many of the minor problems involved with electronic equipment had been adjusted, with the result that traffic was moving more freely with fewer stops along Broad Street, than at any time previously in the history of Philadelphia. Our experience with the cycle-selector system on an arterial street was used to support the opinions of the staff engineers that electronic equipment would be necessary to do the traffic control job in Centre City.

Staff traffic engineers, in co-operation with traffic signal engineers, began to develop plans for a system designed along the lines of the cycle-selector equipment with the same basic master controllers, but for use on a grid-system rather than an arterial street. As work proceeded in this direction, it came to our attention that the firm who had manufactured the

Fig. 3. Pressure traffic detector in street.

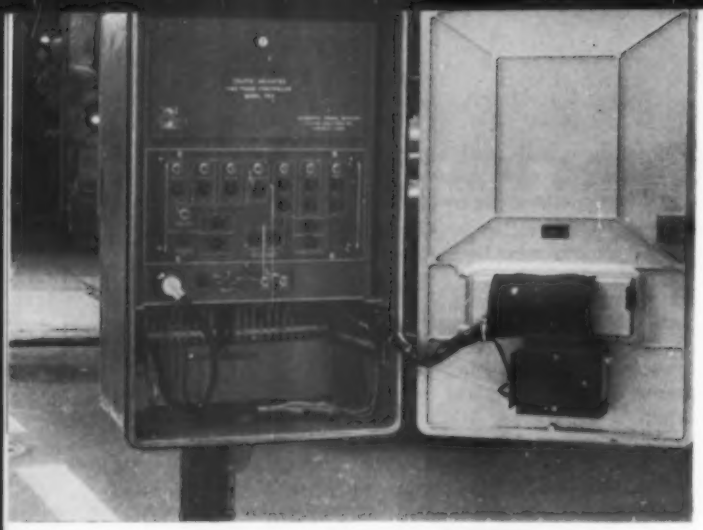


Fig. 4. Local controller.

cycle-selector equipment, already were at work adapting the electronic equipment for use in a grid-street system. For purposes of identification, the equipment being developed was called 'PR' equipment. After thorough study with the manufacturer's engineers and representatives, it was determined that the 'PR' System was the equipment best suited to operate the traffic signals in the Centre City.

The major difference between the cycle-selector system and the 'PR' System is the type of local intersection controller used. Both systems are governed by the same type of master controller composed of analogue computers, selection equipment and generators, In both systems, continuous traffic data from traffic detectors, of either radar or pressure type, in the form of electrical impulses are received by the computers and evaluated. (*Figs.* 2 *and* 3). The computer data then is transmitted to selector equipment adjusted to designate the best signal cycle and directional preference for the measured traffic. Finally, the selector's preference is transmitted to the local intersection controllers by the generators. (*Fig.* 4).

The local intersection controllers vary considerably in the two systems. In the cycle-selector system on arterial streets, the local controllers are generally semi-actuated with detection equipment on the side street. In the 'PR' System for a grid-street system, the local controller is generally a fixed-time electronic device with no local actuation. Principally this difference exists because in a grid-street system all streets are to have progressive traffic movement and thus there is no side street.

The local controller in the 'PR' System is designed to provide flexibility at the intersection compatible with the master controller. (*Fig.* 5). Each local controller is capable of operating on any one of six cycle lengths, at one of five offsets and with one of three splits. Each split is made up of a base period in seconds and an extension in percentage of the cycle length, thus increasing the flexibility. The effect of design is to give the equivalent controls of 18 triple-offset fixed-time mechanical controllers with one electronic fixed-time controller.

The other major variation from the old fixed-time mechanical systems occurs, of course, with the master controller. As previously pointed out, the fixed-time master generally had been regulated and controlled by a weekly programmed timer. The master controller in the 'PR' System on the other hand, has no preconceived timing arrangements, but rather is designed to receive information continuously from the field on traffic volume and traffic directions and is designed to use this information for the operation of the entire system. In simplest form, the 'PR' System is developed on the basis of traffic information continuously feeding into electronic computers which weigh the trends of traffic volumes and the direction of traffic movements, thence furnish the control information to local controllers for the operation of the 320 intersections.

With the selection of 'PR' equipment a new problem developed. This problem was where and how many sampling locations should be established. It was conceivable that traffic patterns in the Centre City area would be so variable as to require scores of sampling locations and it was also conceivable that one sampling location might be found which could accurately indicate all traffic movements. The likelihood was something between these two extremes.

In order to solve this problem, traffic counts by mechanical counters were taken over several months at over 500 locations. The data from these various traffic counts were plotted to indicate the patterns of volume and variation of movement on each street in the Centre City area. The graphs were compared with each other in an effort to find locations giving the most accurate representation of traffic movement at any given time in the whole Centre City area. It was found that in several cases one location represented fairly well a peak-hour movement while another location indicated better the off-peak movements. In several other cases it was found that one location did not accurately measure a variation or trend, but if coupled with another location on another street did give variation and trend information required. In the final analysis, it was determined that within the Centre City area, 10 sampling locations would be required to furnish information for seven electronic analogue computers. Preliminary engineering for the project was now complete and construction could be started.

Estimates of costs were undertaken so that a required appropriation cost could be developed and to determine the benefit-cost ratio as a measure of feasibility. Engineering estimates of costs to modify existing traffic signal facilities to 'PR' requirements,

Fig. 5. Master controller of the PR system.

including conduit and cable, required $565,000. Estimates of new 'PR' equipment and materials installed for the project required another $410,000 giving a total project cost of $975,000, the amount requested for appropriation. Estimates were made of benefits based upon the new journey times which would develop. Using very conservative estimates, such as a minimum reduction of travel time by only 10 per cent and operating costs of 8 cents per minute, a monetary saving of 5.6 cents per trip was estimated. Using only a base of 200,000 round trips into and out of the Centre City daily, a monetary saving would be $11,200 per day. Based upon a 10-year useful life of the equipment, and considering benefits only on business days, the benefit-cost ratio was developed at 33 to 1. In other terms, the system would be paid for in benefits to road users 33 times over the 10-year period. The project was approved and the appropriation was made.

Because of the amount of intensive staff work and engineering which preceded the purchase of the equipment and the actual construction, very few modifications or changes were necessary during the period of construction. In most cases, the changes which took place were because of minor construction problems rather than because of errors in the preliminary engineering and analysis. Construction took slightly less than two years from the beginning of engineering to completion of this project; and by 1958 we were ready to measure the value of the system in improving traffic movement.

A shakedown period of approximately three months was devoted to adjustments in timing, adjustments in the master control equipment, minor revisions at several sampling locations and considerable observation of traffic adjustments. Immediately after this period a complete speed and delay study throughout the Centre City area was again conducted as similar as possible to the studies made in the initial steps. It was determined that delays caused by signals were reduced by better than 60 per cent and the average car speed had been raised from the previous 9 to 12 m.p.h., up to the predicted 15 to 19 m.p.h. Further, it was determined that despite still increasing traffic volumes, traffic moved more freely, the streets appeared to be more open and pedestrians could cross at intersections more easily.

Applying the after study against the estimates which had been made previously in the design and economic analysis of the system, it was found that the benefit-cost ratio estimated to be 33 was now closer to 45, or more than a third more than what was anticipated.

It goes without saying that the traffic authorities of the City of Philadelphia are more than satisfied with the electronic 'PR' System presently controlling traffic at 320 intersections in Centre City Philadelphia. We have found that maintenance costs are lower than anticipated and that the system is able to adapt itself to all variations of traffic conditions which can be expected to occur in such an area.

(*Concluded on page* 271)

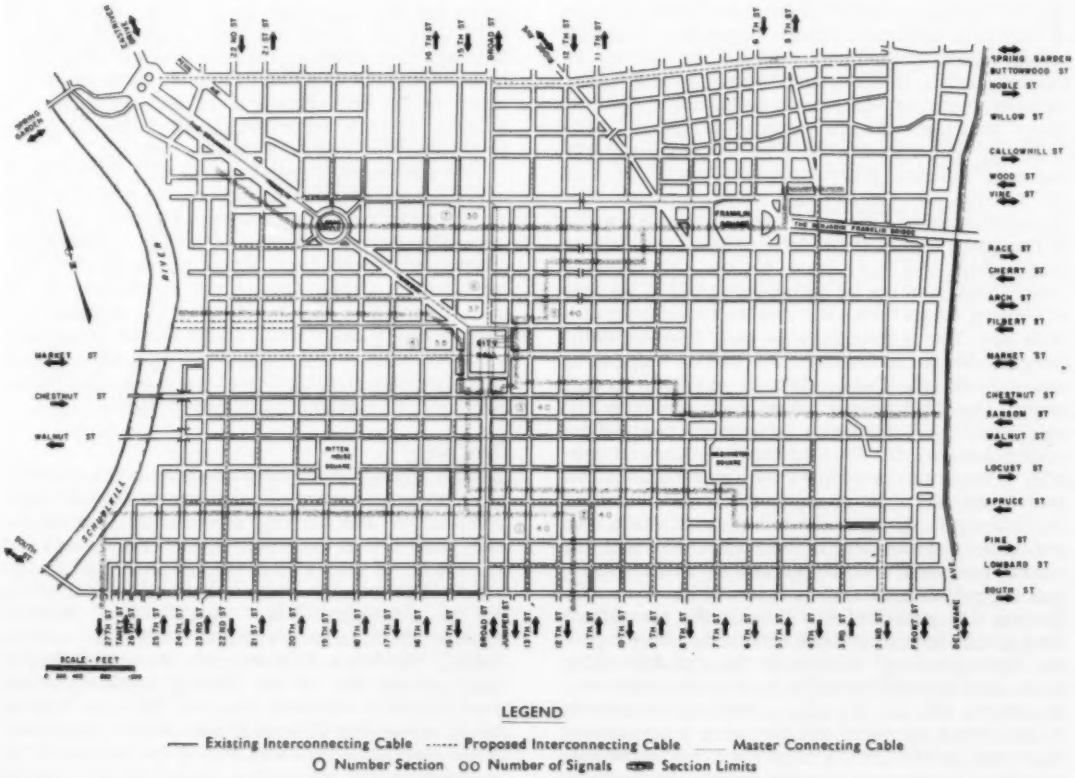


Fig. 6. Recommended Interconnection Plan, Central Business District

GREENFORD ROUNDABOUT EXPERIMENT

by F. V. Webster, B.Sc., Ph.D.

Road Research Laboratory, Department of Scientific and Industrial Research

Fig. 1. Greenford Roundabout.

The problems of roundabouts during heavy traffic are discussed by the author, and a description given of results of installing experimental traffic signals on the approaches to a roundabout at the intersection of Western Avenue and the Greenford Road, Ealing, Middlesex.

FOR a given size of roundabout, traffic can increase up to a maximum volume depending primarily on the traffic composition and on the amount of turning traffic. If the traffic volume is well under capacity, 'weaving' takes place, the sections of roundabout between adjacent approaches being called 'weaving sections'. As the flow increases towards capacity, 'weaving' generally gives way to a 'stop and go' motion as vehicles force their way into the roundabout being followed by other vehicles waiting in the queue behind them. Under these conditions of heavy flow, vehicles, once having got into the roundabout, may not be able to get out of it, because of vehicles across their path, and the roundabout may 'lock-up'. The greater the amount of turning traffic the more likely the roundabout is to lock but locking can still take place when there is very little turning traffic. Once locking has taken place frequently, no vehicles (or very few) pass through the roundabout until it has cleared. Thus the capacity drops temporarily to zero (or to a very low value). Sometimes drivers will themselves free the roundabout, especially if the lock-up is not too severe, but, more often than not, more vehicles try to force their way into the already congested roundabout making matters worse and the police in the end have to sort out the traffic. During this period of low flow in the roundabout long queues have often been observed to build up on the approaches and as soon as the roundabout has been freed the traffic on all sides has once more tried to force its way into the roundabout and immediately it has locked up again. Usually, once a roundabout has locked in heavy traffic conditions (e.g. in the peak period) it is necessary for the police, having sorted the vehicles out, to remain in control of the roundabout for the remainder of the peak period, or at least, until the queues that have formed during the stoppage have cleared. It will be apparent, therefore, that the capacity of a roundabout is unstable—sometimes there is no locking and the capacity remains at a fairly constant value but on other occasions the roundabout locks and the capacity falls off.

The laboratory, in collaboration with the Ministry of Transport, is investigating the effect of installing traffic signals on the approaches to heavily trafficked roundabouts to see whether and in what circumstances locking can be prevented and to determine the effect on capacity. Other aims of the experiment are to ease, if possible, the driver's task of negotiating a roundabout in heavy traffic and to reduce the amount of police manpower needed. Most roundabouts work quite satisfactorily in off-peak periods so the signals need only be switched on in peak periods.

The Site

Several roundabouts have been selected for this study to get a variety of conditions of layout, traffic composition and turning movements. One of the sites studied is at Greenford in the London area and the results of tests at this site are described in this article. The roundabout is situated at the intersection of the Greenford Road (A4127) with Western Avenue (the London-Fishguard trunk road, A40) at Ealing, Middlesex. Unfortunately the scheme had to take account also of the existing signal-controlled intersection at Oldfield Lane on Western Avenue which is less than 200 yards west of the roundabout. A photograph is shown in Fig. 1 and a plan of the roundabout and approaches including the Oldfield Lane intersection is shown in Fig. 2.

Zebra crossings were located on all entrances to the roundabout, and it was considered that they should not be removed since the signals were to operate only in peak periods and the crossings would, therefore, be required at other times of the day. Furthermore, the signals would only afford protection to pedestrians from traffic approaching the roundabout and not from traffic leaving it. It was considered by the police that the signals should be sited well away from the zebra crossings so that drivers after receiving a green signal would travel some distance before reaching these crossings and would treat them in the normal manner, giving way to pedestrians on them. It was also considered that drivers would tend to dissociate the signals from the roundabout and not expect a guaranteed free passage through it. If the signals had been located at the entrances to the roundabout itself there might have been some danger from vehicles entering the roundabout on a green signal and being hit in the side by vehicles already in the roundabout.

It was therefore decided to locate the signals about 200 feet away from the roundabout on Western Avenue and about 150 feet away on Greenford Road. Two primary signals were installed on the Western Avenue approaches and a secondary signal about 30 feet in front of the offside primary. On Greenford Road one primary signal was installed on the nearside and a secondary on the opposite side of the road and about 30 feet in front. Lane lines and stop lines were as shown on the plan (*Fig.* 2).

Times of Observations

Observations were made before and after the installation of signals at the times and on the days shown below:

	No signals
31st March, 1959:	4.40-6.40 p.m.
1st April, 1959:	8.00-9.00 a.m. and 4.30-6.30 p.m.
2nd April, 1959:	7.35-9.35 a.m. and 4.30-6.15 p.m.
3rd April, 1959:	7.40-9.10 a.m. and 4.30-6.30 p.m.
31st July, 1959:	5.00-6.45 p.m.
5th August, 1959:	7.50-9.20 a.m.
7th August, 1959:	7.40-9.10 a.m. and 4.45-6.25 p.m.
	With signals
17th Sept., 1959:	7.40-9.10 a.m.
18th Sept., 1959:	4.55-6.25 p.m.
21st Sept., 1959:	7.35-9.05 a.m.
22nd Sept., 1959:	4.50-6.20 p.m.
19th Oct., 1959:	7.40-9.10 a.m.
23rd Oct., 1959:	4.50-6.20 p.m.

In addition to the above peak-hour observations some observations were made in off-peak hours without signals.

Signal Settings

Because of the proximity of the signals at Oldfield Lane, it was desirable to link the two intersections together in order to minimize delay to Western Avenue eastbound traffic and to prevent the queue from the roundabout blocking the Oldfield Lane intersection. This linking imposed serious limitations on the timings of the signals at the roundabout and also made it necessary to alter the signal timings at Oldfield Lane. The controller at Oldfield Lane is a

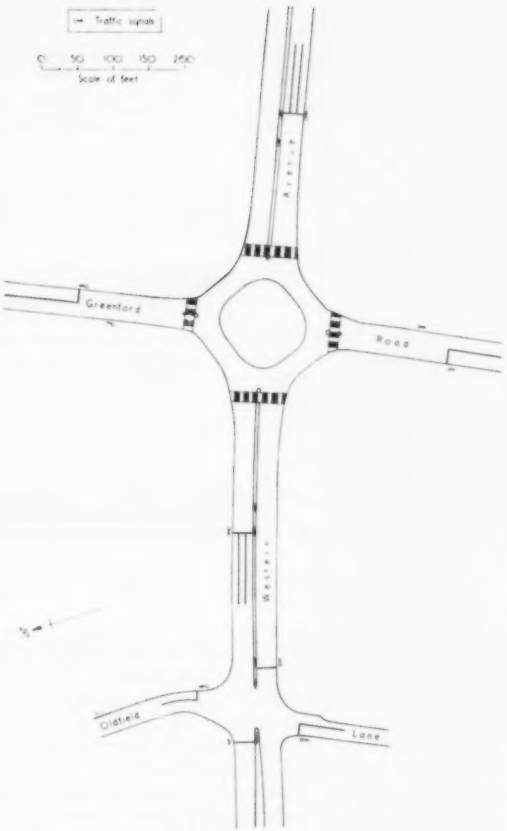


Fig. 2. *Plan of Site.*

three phase vehicle-actuated one working under normal conditions with the following settings:

Western Avenue: 35 seconds maximum green.

Pedestrian phase (operated by push button): 12 seconds, with all-red periods of 3 seconds before and after.

Oldfield Lane: 26 seconds maximum green followed by an all-red of 2 seconds.

When the signals were installed at the roundabout those at Oldfield Lane were altered to provide a three phase, four part, fixed-time cycle. Fig. 3 shows the timings adopted. It can be seen that Western Avenue is followed alternately by the Oldfield Lane green and the pedestrian phase (which now comes in automatically and not by pedestrian demand). The green on Western Avenue at the roundabout commences 12 seconds later than the green on Western Avenue at the Oldfield Lane junction to allow the platoon of traffic leaving Oldfield Lane just enough time to reach the roundabout signals before they turn green. Because of the difference in duration between the green to Oldfield Lane traffic and the pedestrian phase, successive green periods on Greenford Road had to be of unequal lengths as shown in the diagram in Fig. 3. If a permanent system were to be adopted the controller (which should be designed for the job) could easily be made to avoid these large differences in successive green periods.

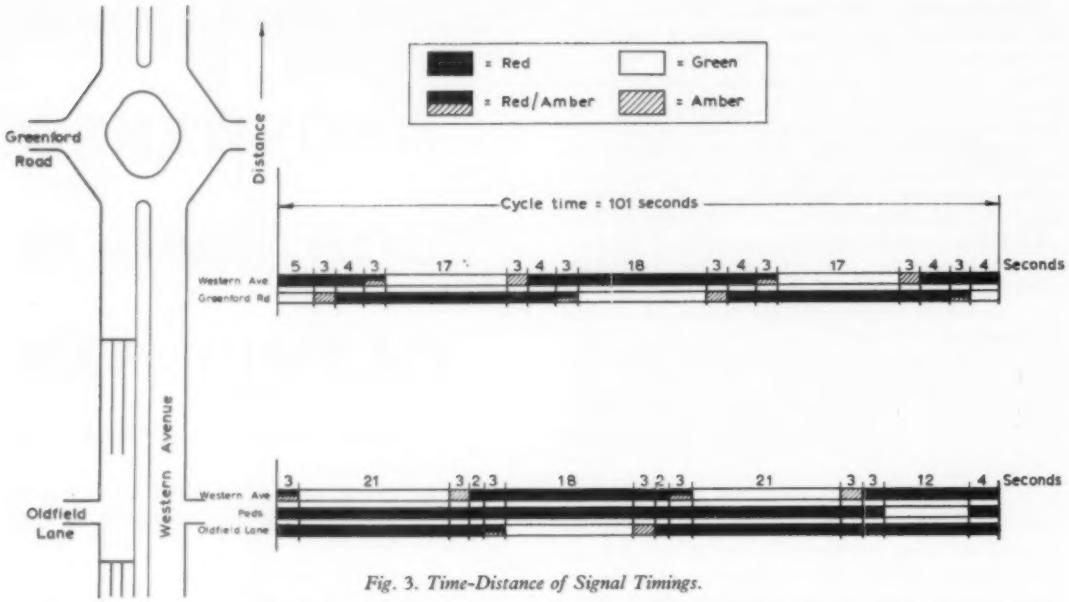


Fig. 3. Time-Distance of Signal Timings.

With long green periods there is the danger that turning vehicles might lock up the roundabout and so the green periods in this experiment were made as short as practicable. With signals at a normal cross-roads short green periods may sometimes be inefficient because the lost time (due to starting delays) becomes an appreciable proportion of the cycle time. At the roundabout under study however, where the signals were placed some distance away, traffic could be started up so as to arrive at the roundabout just before the tail of the cross streams had cleared, thus practically eliminating all lost time. On the safety side, if drivers were taken unawares by a short green period and inadvertently continued after the end of the green the presence of the roundabout ahead should reduce any possible danger.

Observations

Observers with stop watches and hand tallies made measurements, from a tower wagon placed near the roundabout, of flows, delays, turning movements and traffic composition on all four approaches:

Flows: observers counted the number of vehicles entering the roundabout on each approach and recorded the totals every minute. The same observers recorded the number of vehicles every minute passing through each weaving section of the roundabout and classified the state of the flow in one of several conditions ranging between 'free running with gaps' to 'queues present on either entry to the weaving section during the whole minute'. This information was required in studying the capacity of the weaving sections.

Delays: observers, one to each approach, timed vehicles from a fixed 'in' point on the roundabout approach to the point of leaving the roundabout. The 'in' point was far enough from the roundabout to include most queues but not so far so that the travelling time might swamp the delay caused by the roundabout. Observers were told to use the end of the queue instead of the 'in' point wherever the queue extended beyond it, so as to include all the delay. Timed runs of vehicles which were not delayed by other vehicles on the roundabout or by the signals were specially noted, and afterwards an average of such runs was found. The difference between the average journey time through the timed section and the average of the 'unhindered' runs gives a measure of the delay (over and above the normal slowing down due to the roundabout itself). Observers noted also the arm by which the vehicle left the roundabout. As soon as one vehicle had been timed out the observers selected the next vehicle to pass the 'in' point.

Traffic composition: two observers sampled each approach in turn for a period of four minutes counting all vehicles entering, and classified them as:

Light—cars, taxis, shooting brakes, light vans, three wheelers.

Heavy—medium and heavy goods vehicles, buses, coaches.

Turning movements: the proportion of left and right turners and the proportion of traffic weaving in the weaving sections were obtained from the data on the entry and exit points of a representative selection of vehicles recorded by the 'delay' observers.

Results

The average hourly flows in the morning and evening peak periods on all approaches are shown in Table I together with turning movements and traffic composition. Table I shows that the mean flow when the signals were installed was about 8 per cent higher than in the absence of the signals. It also shows the heavy right turning movement (both morning and evening) from Greenford Road (South) and the high proportion of medium and heavy commercial vehicles from Western Avenue (East) during the morning peak. The flows through the weaving sections together with the percentage weaving and an estimate of capacity based on the subjective assessment of the state of the traffic are given in Table II. These capacities are compared with values given by the formula fitted to the Laboratory's weaving tests.[1] The theoretical values are about 8 per cent higher on the average than those observed. The peak hour flows in the various weaving sections are also given in the table and it can be seen that during the heaviest hour of the day each weaving section is loaded to 80 to 90 per cent of capacity.

TABLE I—*Traffic flows on the approaches to the roundabout*

	Peak hour flows (vehicles/h.)				Turning movements (per cent)						Traffic composition (per cent)			
	(No signals)		(With signals)		a.m.			p.m.			a.m.		p.m.	
	a.m.	p.m.	a.m.	p.m.	Left	Straight	Right	Left	Straight	Right	Light	Heavy	Light	Heavy
Western Avenue (East)	910	1,690	1,040	1,775	14	76	10	14	83	3	71	29	90	10
Western Avenue (West)	1,670	1,090	1,735	1,115	8	79	13	9	74	17	88	12	82	18
Greenford Road (North)	490	475	560	545	20	74	6	16	73	11	90	10	88	12
Greenford Road (South)	510	595	555	680	17	57	25	19	58	23	80	20	83	17
Total:	3,580	3,850	3,870	4,115										

TABLE II—*Traffic flows through the weaving sections of the roundabout*

Weaving sections between:	Peak hour flow (vehicles/h)		Per cent weaving		Per cent heavy		Estimated capacity		Theoretical capacity (Ref. 1)		Flow/Estimated capacity (per cent)	
	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.
Greenford Road North and Western Avenue East	2,280	1,615	87	84	12	16	2,695	1,835	2,410	2,310	85	88
Western Avenue East and Greenford Road South	1,420	2,235	89	87	22	11	1,865	2,475	2,320	2,730	76	90
Greenford Road South and Western Avenue West	1,325	2,070	86	91	25	12	1,795	2,340	1,990	2,320	74	88
Western Avenue West and Greenford Road North	2,160	1,660	88	86	18	17	2,615	2,080	2,440	2,500	83	80

Mean delays for successive quarter-hour periods were calculated and plotted against the total traffic entering the roundabout in the same quarter-hour periods. These delay/flow curves are shown in Figs. 4 and 5 for conditions of 'no signals' and 'signals' respectively. (Initially, delay/flow curves were plotted for five minute periods but the amount of scatter tended to obscure the trends). Because some observations were made with no signals in off-peak hours there are rather more experimental points at low flows on the curve in Fig. 4 than on the one in Fig. 5. The curves have been extended with dotted lines to a calculated value at zero flow: with no signals present, a solitary vehicle should encounter no delay at the roundabout (except for the slowing down effect which has been ignored in this study because it is the same with or without signals) whereas with signals the average delay to a solitary vehicle has been calculated to be 0.13 minutes. The curve in Fig. 4 is obtained from observations of delay when the roundabout was working both without control and under police control. These two sets of points cannot be dissociated because the roundabout left to itself could not be relied upon to remain free flowing and, if the police had not taken over control when the roundabout locked, the delay under blocked conditions would not have been represented by the 'normal roundabout working' points on the graph.

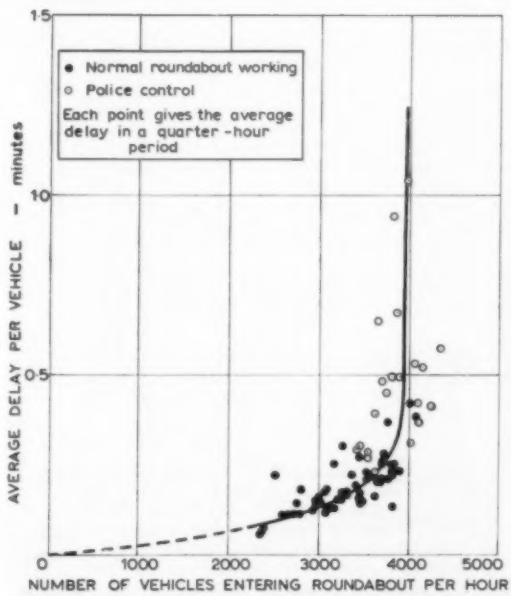


Fig. 4. Variation of Delay with Flow (No Signals).

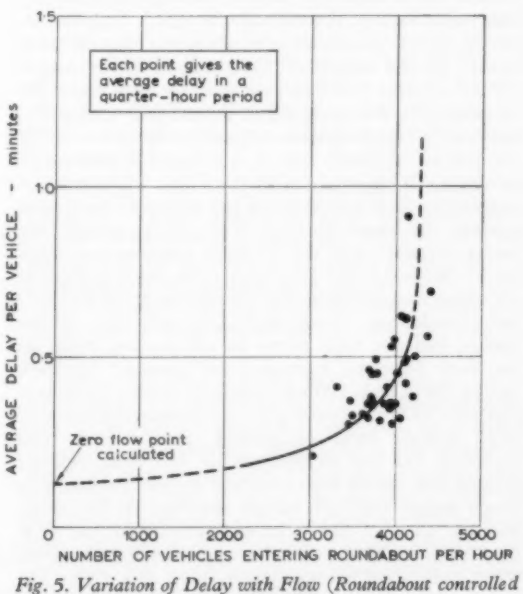


Fig. 5. Variation of Delay with Flow (Roundabout controlled by Signals).

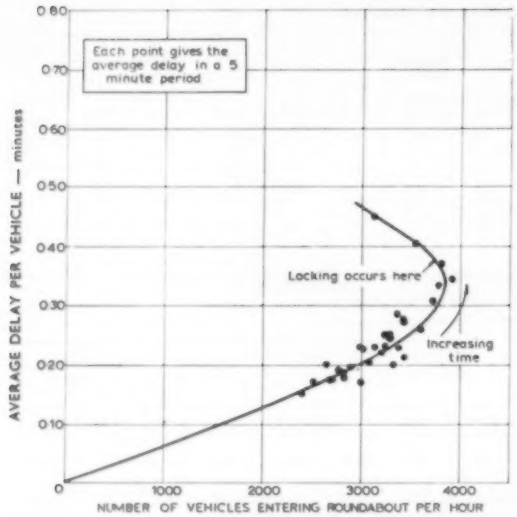


Fig. 6. Delay/Flow curve for a Roundabout on the North Circular Road at the intersection with the Great Cambridge Road, Edmonton.

The delay would probably have been much greater than under police control and the amount of traffic getting through the roundabout might have been much less. An example of locking is shown in Fig. 6 for a roundabout in Edmonton, London, where the police did not take over at the first signs of locking. As fewer vehicles got through the roundabout, queues got longer, and delays increased. Under these conditions the delay/flow curve starts to turn back on itself as shown in the figure. After 10 or 15 minutes the police had sorted the traffic out and taken over control.

The curves of Figs. 4 and 5 are shown together (without the experimental points) in Fig. 7. It is apparent that at the lower flows the average delay per vehicle is less with the roundabout working normally than with signal control and this gives support for having pure roundabout working in the off-peak hours. At the height of the peak, however, signal control appears to be preferable. The capacity of the roundabout without signals is about 4,000 vehicles/h., but under signal control appears to be about 4,300 vehicles/h. (although here it is difficult to estimate it precisely). It has been seen from Table I that without signals the flow was about 8 per cent less than with signals, the morning peak flow being comfortably under capacity but the evening peak only a little under. With the flow observed in the evening peak in the signal control study (4,115 vehicles/h. in Table I) the roundabout would have had difficulty, if the signals had not been there, in passing the traffic as the flow observed exceeded the capacity (without signals) by at least 100 vehicles/h. Although the delays reported in both studies are comparable, opinions of local police, local authorities and drivers who regularly use the roundabout in the peak periods suggest that delays without signal control are normally much higher than the values observed in this study and are often of the order of several minutes. It is possible that drivers tend to remember the occasions when delays are extraordinarily high and forget the number of occasions when they drive straight through, but the relatively low flows observed in the 'no signals' study must have had a considerable effect on the average delay because the delay is very critical in this region of the delay/flow curve.

No results of the effect of the change in signal timings at Oldfield Lane are available but it is unlikely that traffic on Western Avenue was affected to any extent by the change. Traffic on Oldfield Lane, however, was delayed considerably more than usual because its proportion of the cycle time was reduced to allow the pedestrian phase to be included every cycle instead of on demand only. This arrangement was only for experimental purposes and, if the lights at the roundabout were installed permanently, Oldfield Lane traffic would have to be properly catered for.

There seems to be no doubt that at this roundabout the choice does not lie between pure roundabout control and signal control but between roundabout control with police assistance (when locking takes place) and signal control. Some aspects of delay and capacity considerations have been outlined above and other aspects are mentioned below. Signal control has the advantage over police control that an intricate timing scheme based on average flows can be worked out in advance and applied accurately. The signals are definite and a traffic stream can be interrupted more easily, but, on the other hand, police can see if the roundabout is tending to lock and take appropriate action immediately. They can also deal on the spot with turning traffic and make effective use of any gaps in the streams for the benefit of waiting traffic. Co-ordination between three or four policemen controlling a roundabout is, however, difficult.

With the signal control tried at Greenford there was some danger of locking resulting primarily from locating the signals so far back on the approaches. When pedestrians on the zebra crossings, or a slow moving vehicle, delayed a platoon of vehicles entering the roundabout then the tail of that platoon sometimes

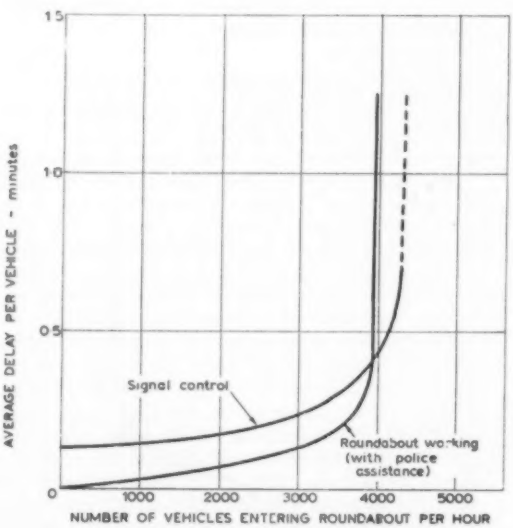


Fig. 7. Comparison of average Delay/Flow curves, with and without signals.

delayed the next platoon from the side road which in turn delayed the main road traffic and so on. Usually the situation sorted itself out after one or two cycles, but, occasionally, the traffic got more and more out of phase with the signals and, eventually, the roundabout locked up. If the signals had been placed at the entrances to the roundabout there would have been less danger of this happening because any delay to the stream of traffic having right of way would have resulted in fewer vehicles entering the roundabout in that cycle and the traffic would have kept in step with the signal timings.

In the experiments reported here there was no safeguard against this sort of locking-up occurring but recently a manual 'all-red' switch has been fitted to the controller which when operated allows the signals to cycle round to the next all-red period where they remained until the switch was turned off. By suitable use of this switch blockages can be averted by one policeman. Even if one did occur the traffic in the roundabout could be sorted out whilst all traffic arriving remained behind red signals. One of the difficulties that police experience is that fresh arrivals often hinder them whilst they are trying to free a roundabout. Experiments are planned to investigate the possibility of an automatic all-red extension using 'presence detectors' to indicate to the controller when some vehicles from a previous cycle have still not entered the roundabout. In these conditions the controller would withhold the green for this phase until the detectors give the 'all clear'. Until this is developed, however, one policeman should be in attendance at a signal controlled roundabout, while the signals are on, to operate the manual 'all-red' switch if necessary.

It has been suggested that roundabouts which are congested in the peak periods could be removed and replaced by normal signal controlled intersections. There are, however, certain advantages in having signal control of roundabouts in peak periods and reverting to normal roundabout working for the remainder of the day:

(i) The delay is less in the off-peak period with roundabout control than with signal control.

(ii) Signals at a roundabout can work on a shorter cycle (which is beneficial to right turning traffic) than would be possible both on safety and delay grounds with ordinary signals. Traffic can be released so as to reach the roundabout just before the tail of the cross-road traffic has cleared, thus reducing 'lost' time resulting from a change of right of way. (Lost time can become an appreciable proportion of the cycle time with short cycles at normal signals).

(iii) The roundabout itself provides a storage for right-turning vehicles, and this treatment, therefore, lends itself to junctions with complicated turning movements.

(iv) Minor approaches with low volumes of traffic need not be signalized The traffic can be allowed to filter into the roundabout at any time.

Conclusions

(i) Without signal or police control the operation of the roundabout was found to be unstable when it was heavily loaded. Depending on driver behaviour, the roundabout could lock-up under heavy flows with a consequent reduction in capacity (and therefore flow through the roundabout) and an increase in delay. The roundabout is therefore unsatisfactory without any form of control in periods of heavy flow.

(ii) Signal control increased the capacity of the roundabout over police control from about 4,000 vehicles/h. to about 4,300 vehicles/h.

(iii) During the height of the peak the delays were about the same under signal control as without signals but the flow was eight per cent higher. During the lighter periods of the peak hour the delays were greater with signals. As traffic increases the benefits from signal control would be expected to increase.

(iv) From opinions of drivers it was evident that they preferred signal control, where movements were more orderly, to the 'cut-throat' behaviour of a congested roundabout. Opinions were expressed that delays under normal conditions were on many occasions extremely high.

(v) Signal control of the existing roundabout has certain advantages, as listed above, over removing the roundabout and constructing a normal signal controlled intersection.

(vi) At present because of the zebra crossings and the occasional slow moving vehicle there is still the possibility of the roundabout, when signal controlled, locking-up. One policeman is therefore required to operate the manual 'all-red' switch to prevent locking. Under manual operation, without signals, several policemen were sometimes standing by in case of a blockage. Signals should, therefore, reduce police manpower at this roundabout.

Acknowledgments

Thanks are due to the County Surveyor of Middlesex and his staff, the Metropolitan Police and the Automatic Telephone and Electric Co. for the valuable help given during this experiment The experiment was carried out as part of the programme of the Road Research Board of the Department of Scientific and Industrial Research. The article is published by permission of the Director of Road Research.

REFERENCE

[1] WARDROP, J. G. The traffic capacity of weaving sections of roundabouts. Proceedings of the First International Conference on Operational Research (Oxford 1957). London, 1957 (The English Universities Press Ltd.), pp. 266-80; Discussion 280-1.

Philadelphia's Signal System (*Concluded from page* 265)

The equipment has been dependable and has controlled traffic so satisfactorily that plans are now underway to expand the area controlled by this system both to the north and to the south. The area of expansion will be on streets not a part of Centre City, but ones which traffic variations and characteristics are similar and compatible with traffic conditions in Centre City.

Although the original equipment which was installed is interconnected by underground cable, recent research in electronics now make possible this equipment being interconnected by radio and it is probable when our expansion of the system begins within the next year, the interconnection will be done by the use of radio rather than by electrical wire at a much lower cost.

The result of installing and utilizing the 'PR' equipment controls in Centre City Philadelphia has been to modernize its 26-foot streets so as to enable them to carry 1960 and 1965 traffic volumes, without the high cost of widening and major reconstruction. The results have been so outstanding, that the responsible authorities in Philadelphia are convinced that electronics and electronic signal controls are now essential to the efficient management of traffic in the large metropolitan areas.

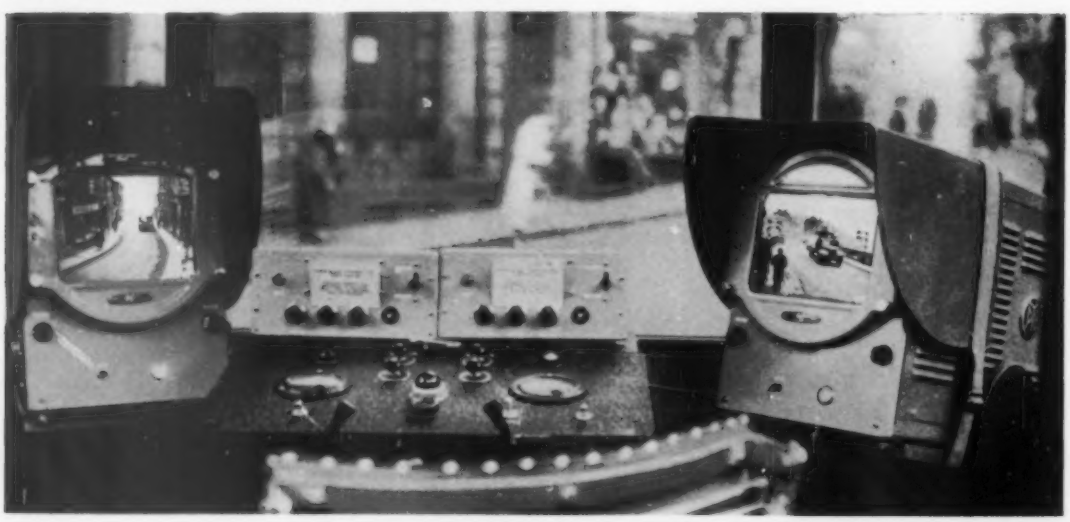
The photograph on the left shows the entrances to the new underground garage in Downtown Brooklyn. This garage is built below a landscaped plaza and is designed for short-term parking by shoppers at nearby stores. It can accommodate up to 700 cars.

PROJECTS AND A

IN PI U

The recent improvements in the accuracy of speed timing equipment require the regular checking of speedometers. This stretch of road in America is marked at one mile intervals and is such that a constant speed is possible for several miles. By timing his car over this stretch, a driver can check the accuracy of his speedometer with little trouble.

Below. The two television monitoring screens described on page 298.



On the right is shown one of the 300 ft. by 290 ft. parking levels of the new Brooklyn garage. There are three such levels with two side levels sloping in opposition. The aisles are 23 ft. wide between parking stalls 8 ft. 8 in. wide and 18 ft. 6 in. deep.

AND ACHIEVEMENTS

I PICTURES

At the new service area at Newport Pagnall on M1, the sign shown in the photograph (right) indicates the position of the area and the services available. This is the forerunner of many similar signs and tells its message clearly and simply by the use of symbols which are unmistakeable to English and tourists alike.

Below. Part of the improvements to the Great North Road near Grantham.

Traffic Studies

CAPE TOWN

by Dr. S. S. MORRIS, *City Engineer*

A COMPREHENSIVE traffic survey was carried out in Cape Town during 1956. The initial survey and analysis of data took approximately 18 months to complete; up to a maximum of 60 persons were employed and the cost was approximately £13,000. The area surveyed (part of the metropolitan area of Cape Town) has a population of about 600,000, and 80,000 to 100,000 vehicles are registered in the area.

It is only within the last three to five years that properly organized comprehensive traffic surveys have been carried out in major South African cities. Previously, planning schemes were perforce prepared, so far as traffic desiderata were concerned, largely on the basis of empiricism and judgment. Proposed road improvements were incorporated in planning schemes but the traffic problem was not scientifically investigated, although the broad features might well have been visualized. To use medical analogy, remedies applied were like especially potent antibiotics which cured the ill without the need for accurate diagnosis.

In Cape Town detailed investigations have, fortunately, confirmed that the original prescription —based largely on broad analysis, judgment and study of trends in other cities, particularly in the U.S.A.—required little amendment. The traffic survey has indeed proved most fruitful, and has led to a number of valuable amendments, both to the overall road pattern proposals and to the more detailed planning and design of freeways and major arteries.

Planning Traffic Surveys

The need for clearly defined and specific objectives is particularly important, even in the initial planning of traffic surveys. A survey should not be planned merely to provide a haphazard collection of data, but rather to assist in the solution of specific problems. These include:

(i) The evolution of a satisfactory overall road pattern.
(ii) The desirable classification of different highways and determination whether they should be treated as freeways, at-grade expressways, or as major streets.
(iii) Provision of data governing the qualitative nature of treatment at intersections: the desirability or otherwise of grade separation, the relative importance of the various direct and turning movements and the need to eliminate undesirable weaving movements.
(iv) Provision of quantitative data enabling calculation of number of lanes, signal timing and phasing, weaving lengths, etc.

Fortunately, many, if not all these objectives, do not necessitate extreme numerical precision either in analysis or in forecasting.

The traffic surveys carried out in Cape Town fall into three main groups:

(i) Origin and Destination Surveys (for overall road pattern).
(ii) Parking Surveys.
(iii) Volumetric Counts and Speed and Delay Studies (for analysis of intersection design).

Principal source of data for analysis is the origin and destination survey, other surveys being useful mainly as supplementary to or in confirmation of the findings of O. & D. analysis.

Origin and Destination

The first steps in undertaking an O. & D. survey are subdivision of a city into a reasonable number of zones each of a fairly homogeneous character, and counting the trips carried out on a particular day between each pair of zones. For this purpose a postal questionnaire was circulated to every motorist whose car was registered in the Cape Town metropolitan area requesting information regarding all trips undertaken on the survey day. Similar information was collected from visiting motorists by stopping and questioning cars entering the city on the main approach roads. Data collected was processed and tabulated by punch card machinery. The raw data collected from the survey was adjusted so as to correct for questionnaires not returned. The results obtained were then checked against actual volumetric counts taken on various screen lines and also against the figures found in the parking card survey, fully satisfactory agreement being found. Desire line maps were then prepared indicating existing characteristics of desired motor travel within the city. Once present-day conditions had been established and checked, extrapolation of data for future conditions was undertaken, the objective being tabulation of inter-zonal trips for the design year, taken as 25 years in advance.

Forecast of Growth Factor

Forecasts of growth factors are easier and more accurate if they commence with the metropolitan area as a whole—the complete sociological unit—and later proceed to consideration of zones. A satisfactory overall parameter on which to base such analysis is the city's total motor vehicle registration.

Forecasts of increase may be made in a number of ways. Data for previous years may be charted and then extrapolated either logarithmically or arithmetically. More elaborate extrapolations can be made employing analysis of both population growth and motor car registration per capita. A still further alternative method is use of analogy of growth of motor registrations with growth of demand for other commodities such as water. All these methods were used in the Cape Town survey, but most reliance was placed in the last, since a particularly strong linear correlation was found between water consumption and motor vehicle registration. Furthermore, considerable confidence could be placed in water consumption forecasts since departmental forecasts prepared as far back as 1950 in the planning of the recently completed Wemmershoek scheme had been fully verified by subsequent experience.

Zone Generating Capacity

By detailed analysis, overall growth of motor vehicle registrations was then allocated in varying proportions among different zones; some of these will remain almost static—others again will expand rapidly.

For the majority of zones, trip generating capacity may be taken as being roughly proportional to motor vehicle registrations. For the central business district (C.B.D.), however, special analysis is necessary, since the number of motor car registrations within this zone is not of significance. Furthermore, in large cities such as Cape Town, the effects of decentralization, in particular the movement of commerce to the suburbs, have a marked effect on the number of trips to the C.B.D., the rate of growth of trips to which lags significantly behind the growth either of total population or of vehicle registrations for the city as a whole. Forecasts for the C.B.D. should accordingly also pay special attention to comparisons with known cordon counts in cities already of a size approximating to the forecast population for the design year of the city under study.

For the Cape Town analysis particular attention was paid to data available in such cities as Baltimore, Cleveland, St. Louis and Melbourne. These indicated that a growth factor of two for trips to the central business district would be appropriate. The overall growth factor assessed for inter-suburban trips, however, is, on the average, about three or four.

Forecasts of Interzonal Trips

The rate of increase of trips between two zones with different rates of growth was taken as being the arithmetic average of the two zonal rates. This simple procedure has now been abandoned in recent United States analyses, where extremely elaborate techniques, using procedures similar to the Hardy Cross method of moment distribution, are employed. Immense volume of calculation is necessary, and use of electronic machinery essential. Under conditions in Cape Town, however, it was doubtful whether the general accuracy of forecasting was sufficient to warrant such complicated procedures in the investigations.

Having completed the above preparatory work it was then possible to chart both existing and forecast volumetric desire lines, thus giving a pictorial representation of the number of trips desired between the zones of the city both nowadays and in the design year 25 years ahead. Since, ideally, a road should convey as many people as possible in the most direct route between origin and destination, charts such as these are often a useful guide in evolving an overall road pattern. They are, however, no more than a guide, because the pattern must often be modified,

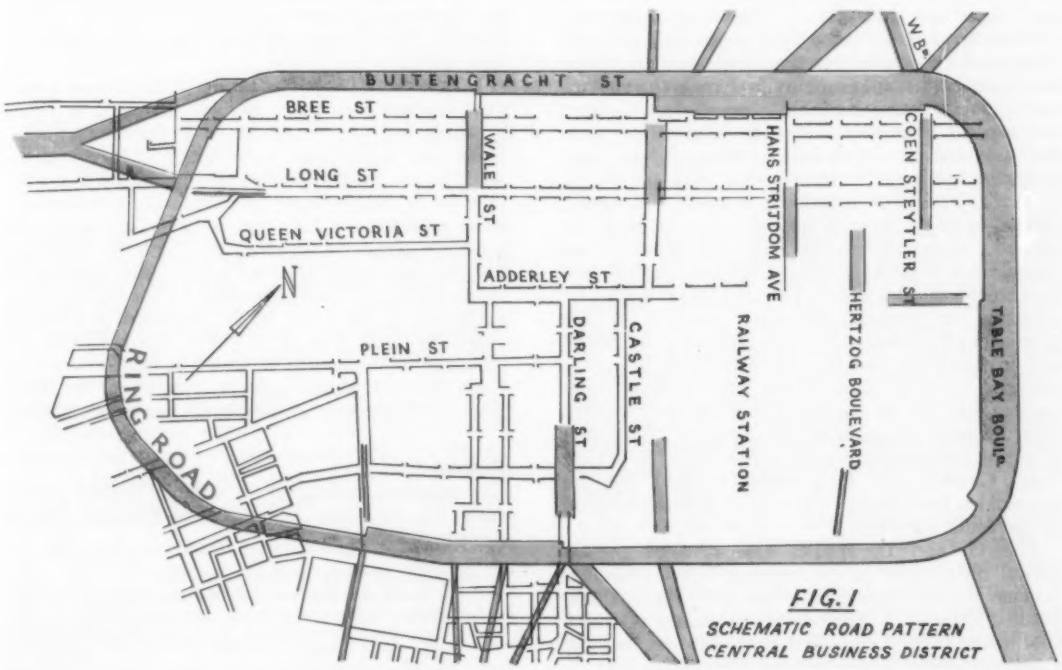


FIG. 1

SCHEMATIC ROAD PATTERN CENTRAL BUSINESS DISTRICT

sometimes considerably, to fit topography and existing road and rail systems, and also to comply with town planning and zoning desiderata.

Overall Road Pattern

Indeed, in Cape Town the modifying factors were dominant. Two major national roads (N9 to Johannesburg and N2 to Port Elizabeth) had already been planned and formed the first components of the freeway system. The plan required also to make provision for an additional major route to Sea Point in the West, and topography and site values determined where this should be placed (the route so determined has been called Boulevard West).

The desire line studies indicated that the principal traffic flows for which the main road pattern had to provide were those from the suburbs to the C.B.D.; consequently, two schemes given first priority in an initial three-year construction programme now under way are two radials from the southern suburbs to the central city, one above the main suburban railway line (the de Waal Drive route) and the other below the railway line (the Black River Parkway, Milner Road, Prince George Drive route). The desire line studies also indicated a large volume of traffic wishing to travel between the southern suburbs and the northern areas (Goodwood, Parow and Bellville), and for this reason special emphasis was placed on the Park Road, Pinelands Drive, Viking Way, Vanguard Drive route which will cater for this traffic. The need for cross-connections between the various radials was, of course, apparent; these, however, were already provided in the town planning scheme.

Future Traffic Flow

The detailed O. and D. traffic analysis provided a forecast of future traffic flow along all the new radials. This helped decision regarding the type of treatment that would be desirable on each (e.g. freeway, expressway or streets with fully controlled, partially controlled, or uninterrupted access). Moreover, the number of traffic lanes required to handle the volume could then be determined. Full forecast data of direct and turning movements at each intersection were also provided by O. and D. analysis. These data indicated the type of intersection that should be provided (e.g. grade separated, at-grade with traffic signals, or at-grade with stop streets), the need for specially designed features (e.g. the provision of special links to cater for heavy right-hand turns), and the extent of any road widening that might be necessary to provide adequate storage on the approaches to signalized intersections; the nature of any provision that would have to be made to permit adequate weaving movements, and various other matters that arise in designs of this nature connected with the provision of adequate capacity. The design of every intersection forming part of a Ten-Year Road Construction Programme adopted by the Council has been based on O. and D. figures provided by the traffic survey.

The O. and D. studies also revealed certain critical deficiencies in the existing Town Planning Scheme for the central city (the 1947 Plan). Using detailed O. and D. analysis of the nature of traffic flow in the central area, new proposals (set forth in a comprehensive report entitled 'Freeways, Parking and the Civic Centre') were evolved. Desirable development of the road pattern in the vicinity of the C.B.D., however, could not be assessed by desire line charts; instead, detailed O. and D. routing studies, as described below, formed the basis of planning.

Central Business District Analysis

The actual pattern of C.B.D. streets is normally too complex for routing analysis and the first step, therefore, is preparation of a simplified analogous pattern. This pattern for Cape Town is shown in Figure 1. Its principal features are a ring road, a number of entries to it from the radials or tangent roads, exits from the ring to the C.B.D. and (a special feature brought about by Cape Town's topography), the crossings of the Adderley Street-Heerengracht axis, which forms a barrier to cross-town traffic. Each road entry, exit and crossing is treated as a unit, although in fact two or more roads may exist or be planned. The southern Adderley Street crossing, for example, hereafter treated in analyses as a unit, comprises no fewer than nine streets.

O. and D. forecast flows were routed through this simplified pattern. In the analysis the 'all or nothing' system was employed (except in doubtful cases where an arbitrary split among alternatives was sometimes used). This is still an accepted technique, although in many American analyses it has now been abandoned in favour of elaborate investigations whereby trips are split among alternative roads on a formula based on the relative distance and travel times involved. But with such investigations calculations are extremely lengthy and electronic devices must be employed; moreover, the resulting added accuracy is of doubtful value bearing in mind the uncertainties in basic premises.

The routing so arrived at must then be checked to see that existing streets are not loaded above design capacity. Where they are, flows must be unloaded to new routes.

In analysing capacities of signal controlled intersections, use was made of both the British Road Research Laboratory and the U.S. Bureau of Public Roads sets of formulae. Comparison of the formulae with volume study field data in Cape Town indicated that the British formulae appeared to be substantially more accurate, the American formulae giving results generally conservative, often very unduly so. These findings have since received some confirmation in a recent article in *Traffic Quarterly* by the leading U.S. authority in this field, O. K. Norman: in his new charts the U.S. Bureau of Public Roads figures are amended substantially upwards. Current work in Cape Town is, accordingly, now based on the Road Research Laboratory and the latest Norman formulae.

Results

The principal findings of the detailed studies undertaken for the Cape Town central business district were as follows:

(i) *Adderley Street-Heerengracht Axis*

Fears that this axis would form a barrier to cross-town traffic movement were confirmed. The cross-town flow pattern of the original 1947 central plan was clearly revealed as being inadequate. Routing on this pattern disclosed heavy peak-hour

congestion at intersections along the axis, which could be relieved only by unloading. The most effective way of doing this was by assigning traffic along a ring road route instead of cross-town.

(ii) *Eastern Leg of Ring Road*
Perhaps the most serious problem of cross-town flow is posed by the at-grade intersection at the junction of Hertzog Boulevard (extension of Boulevard East) and the Heerengracht, which forms a feature of the 1947 plan. The proper solution is diversion of the Boulevard East traffic away from Hertzog Boulevard and into the ring road, as set forth in the report 'Freeways, Parking and the Civic Centre'.

(iii) *Northern Leg of Ring Road*
The 1947 design of this portion of the ring road treated intersections as ordinary traffic circles—a design which more advanced knowledge has shown to be grossly inadequate as a terminal for a six-lane freeway. Full freeway treatment with the road taken on viaduct is now proposed.

(iv) *Western Leg of Ring*
Studies brought out clearly the probability of very severe loading of this section of the ring road, which is brought about by two factors: firstly, that the heavily trafficked Boulevard West will join the ring road in this vicinity, and second, the majority of destinations within the cordon area for traffic from the east lie on the western side. This section has accordingly been designed as a freeway as far as its terminal in the C.B.D.; from there it will comprise two one-way streets up to the junction with the southern leg of the ring road. On this portion of the ring road a large directional interchange is proposed for the intersection of Boulevard West and Table Bay Boulevard, the so-called 'Western Exit' to the Foreshore.

(v) *Southern Leg of the Ring Road*
When proposals for a ring road in Cape Town were originally put forward in 1951, the above section of the scheme, in particular, met with considerable opposition in certain lay circles, and even among some engineers. Indeed, the controversy continued until fairly recently, and full authorization for the scheme has not been obtained to date. The traffic analyses, however, demonstrated clearly that this proposal should form part of the Town Planning Scheme. Ultimate flows are very substantially in excess of capacity of existing streets, even if widening is undertaken, and an expressway type southern leg for the ring is, therefore, essential. It is perhaps one of the most fruitful results of Cape Town's traffic investigations that this controversial matter has been removed from the sphere of subjective opinion and irrational argument, and instead is now based firmly on objective quantitative data.

Parking Analysis

Comprehensive parking surveys of both the kerb and card type were undertaken, from which analysis was made not only of the extent and nature of the parking problem but also of desirable solutions, these taking the form of parking meters and central city parking garages.

A kerb survey was made in which note was taken of all cars parking within the C.B.D. with a view to ascertaining actual parking characteristics within that area. A similar card study was made to ascertain the desire characteristics of parking there. Cards were handed to all motorists entering the area at selected points within a cordon surrounding the central city. Motorists were requested to complete the card by filling in data giving full details of all visits paid within the district. Cards were collected at the cordon points when cars left the central city.

Peak-hour volumes of vehicles parked around each block in the central business district were indicated on a map of the city by bar diagrams, the number of spaces legally available around each block being similarly plotted. These maps and statistical studies provided comprehensive information regarding such parking characteristics as areas of parking congestion, extent of illegal parking and turnover rates in various blocks. A map of the city was prepared showing peak-hour demand for parking in each block of the city as against the amount of parking legally available. A similar map was also prepared showing the position in respect of short-term parkers only (those parking for less than two hours). These maps and supplementary statistical analysis provided data permitting assessment of the need for parking garages and for parking meters.

Application of Studies

The parking studies afforded a basis for planning the proper positions of future parking garages—a feature which is bound up with the planning of a comprehensive road system for the central business district. Traffic analysis has proved invaluable in determining the overall road pattern and also in settling patterns and details of intersection design.

Complete 24-hour traffic counts were made at every major intersection inside the metropolitan boundary, the volumes of all types of movement, both direct and turning, being tabulated at 15-minute intervals. On selected major roads more extensive counts were taken, so as to establish not only diurnal but weekly, monthly, and annual fluctuations in the traffic flow pattern. Screen counts were taken covering all approach roads on the western and eastern entries to the central business district. Speed and delay studies were undertaken at all major routes between the city and suburbs, average speeds of traffic and degree of congestion at bottlenecks being noted.

Volumetric counts were plotted on maps of the city so that existing patterns of traffic flow could easily be visualized and the presence of congested areas noted. The findings of these studies were plotted on graphs, distance travelled being plotted horizontally and time taken vertically. The slope of the graph gave immediate demonstration of average speed, and of the presence of bottlenecks causing delay.

In the planning and design of the new road schemes, O. and D. analysis was the principal tool. The volumetric counts and speed and delay studies, however, yielded valuable subsidiary data. These studies in conjunction revealed existing bottlenecks, and gave a basis for deciding which portions of the future road pattern should be given priority in construction. The speed and delay studies were most useful in assessing the benefits that will be derived by the motorist from new construction in lessening congestion and in reducing travelling time between various points.

To summarize, the data provided by the traffic survey, and the analyses that have been carried out utilizing this data, have yielded a most valuable basis for the planning of the overall road pattern of the central city, for the design of various projects forming part of the City's present £15 million Ten-Year Road Construction Programme, and for assessing the degree of priority of these projects.

Origin–Destination Survey

BIRMINGHAM–PRESTON MOTORWAY

by H. COWLING

Ministry of Transport

ONE of the motorways proposed in 1949, when the Special Roads Act became law, was a road running northwards from Birmingham to the neighbourhood of Preston. Towards the end of 1955 it was decided to take an Origin and Destination Survey in order to obtain the basic information needed for design of this motorway i.e. for the carriageway width required and for the junction siting and layout. It became necessary to decide what method should be used to take this survey and how the points should be located.

Method Used

There are five ways by which an Origin and Destination Survey may be taken. These are:

(a) By stopping drivers and questioning them as to their routes, origins and destinations.

(b) By stopping drivers and asking them to fill in and return prepaid postcards. The necessary questions are shown on the cards together with the time of issue, and survey point number.

(c) By noting the registration numbers of vehicles at various points and so tracing the paths followed.

(d) By sticking coloured tags on vehicles. If the colours of the tags on vehicles are noted as they pass other survey points, their paths can be traced.

(e) By questioning people in their homes and hence obtaining information as to the journeys they may make.

The survey was taken by interrogation, which seemed to offer advantages over all the other methods. For instance, home interviewing has been used in the United States for city planning in which the great majority of users of any new facility will be drawn from the city and its immediate area. But for a motorway survey, where the users may have their homes in any part of the country, it was certain that there would be a very large proportion of wasted interviews.

The postcard system is satisfactory only if the majority of cards are returned. In surveys taken in this way more than half the drivers stopped have failed to return their cards, and, the percentage returned has varied for different classes of users. This form of survey introduces a 'bias' to the results, but the direction of this bias and its magnitude cannot be forecast.

The tag method is useful for tracing vehicles through a city when it is required to know the diversion of traffic between several routes. The registration number method is also useful for this purpose. But both these methods suffer several disadvantages which rendered their use impracticable. If any road by which drivers entered or left the motorway area had no census point on it, the through drivers on that route would have been counted as stopping or originating traffic instead of motorway traffic and this would have produced an error in the result. Then it is almost impossible to determine with satisfactory accuracy whether drivers have stopped in the census area or not. Last of all, whether a driver will use a motorway will be determined to a large extent by the area he has journeyed from, how far it is away, and in what direction it lies from the motorway. These facts cannot be found out without very considerable complication by either the tag or registration number methods.

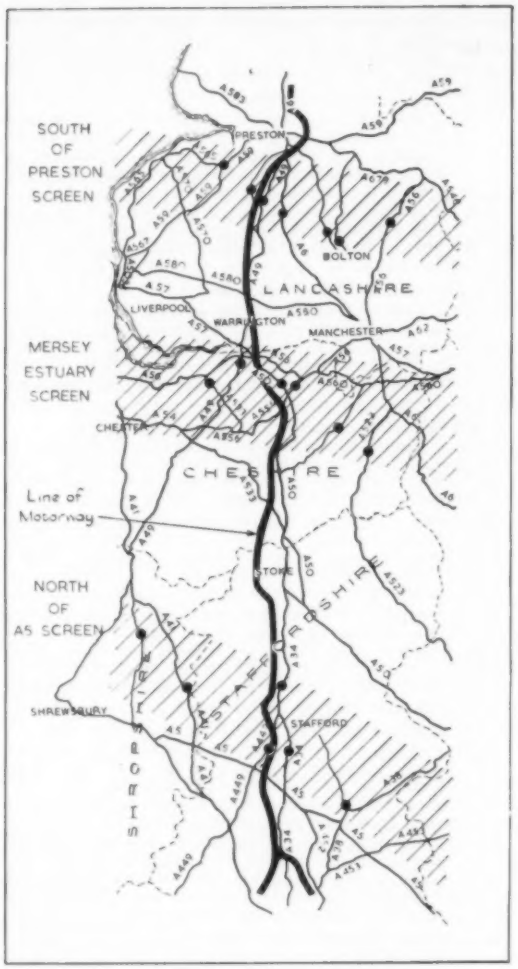


Fig. 1. Location of census points.

The interrogation method on the other hand, had many good features which led to its adoption. The areas the driver has come from, and is going to, can be found directly. A further valuable feature is that compulsory stops which have to be made at a certain place, such as calls on business, can be distinguished from voluntary stops such as those for petrol and

meals, which can be made at any point on the journey. Then, the number of vehicles stopped can be varied by using sampling, so that the amount of information obtained is sufficient to get satisfactory accuracy without collecting a lot of unnecessary information. Last of all, because each interrogation census point is self-contained, considerable flexibility in siting the points is obtained.

Generally, the points for a survey to determine the use of a new road are sited along the route it will take, near each point at which it will join or cross an existing road. But a motorway will draw its traffic from roads lying a considerable distance from it, and siting the points only along its course would lead to a considerable amount of potential motorway traffic being lost.

It was decided, therefore, to site the points not along the course of the road, but in screen lines lying roughly at right angles to its course. This arrangement ensured that there was virtually no likelihood of a driver being counted twice, or missed completely, for in each screen all major roads which crossed the screen line had one point, and one only on them. The screens were kept entirely independent for analysis of the results. There were three main screens, one at the northern end of the motorway just south of Preston running from the west coast eastwards to route A56 at Edenfield, a second running eastwards from the Mersey Estuary, south of Warrington and Manchester, to route A523 north of Macclesfield, and the third running eastwards from A53 at Hodnet between Shrewsbury and Market Drayton to A34 north of route A5. There were 19 points in all: the positions are shown in Fig. 1.

Questioning continued for three days. It had been found previously that traffic on the five week-days does not vary sufficiently day to day to justify questioning over the whole week. The proportions of short-distance and long-distance traffic are also approximately constant for the five week-days. The survey was therefore taken for three days, Friday, Saturday and Sunday at each point. As a result of experience in this and other surveys, however, the days now used are Saturday, Sunday and Monday. Typical figures, obtained in a similar survey in Leicestershire for the northern extension of M1 are shown in Table I. The traffic on Friday may be affected by drivers making an early start for the week-end or by local traffic on pay-day.

TABLE I

	Traffic to Local Areas	Traffic to West Riding	Traffic to East Riding	Traffic to Nottingham	Traffic to Cumberland & Scotland
7 day average	1,692	696	269	1,345	110
3 day Average-Fri/Sat/Sun.	2,785	836	395	1,338	144
3 day average-Sat/Sun/Mon.	1,813	722	216	1,382	115
Week-day average	1,545	695	230	1,514	106
Friday traffic	3,063	865	418	1,501	140
Monday traffic	1,704	704	147	1,561	96

The questioning was carried on throughout the 16 hour period 6 a.m.-10 p m
Four questions were asked: these were:
1 *'Where did you start your journey today'?*
2 *'Where was your last stop excluding meal breaks'?*
3 *'Where is your next stop excluding meal breaks'?*
4 *'Where will you end your journey today'?*

It was not known what proportion of drivers had to make compulsory stops such as business visits along their journeys. If, as was believed, the proportion was quite high, the positioning of these stops could have had a considerable influence on the use of the motorway. The second and third questions were included to find out the details and frequency of these stops. The only other details recorded were the classes into which the vehicles fell: motorcycles, private cars, public service vehicles, light goods vehicles, and heavy goods vehicles. Public service vehicles on local routes were not stopped as they would not have used the motorway, and neither were pedal cyclists. The division of goods vehicles into 'light' and 'heavy' was made using the 30 cwt. unladen limit which is also used to discriminate between goods vehicles counted as one passenger car unit or three passenger car units.

In order to reduce the amount of information to be dealt with to the smallest volume compatible with a reasonable standard of accuracy, sampling was used. The form of sampling used was 'fixed fraction' sampling. In this, it is decided beforehand what proportion of drivers are to be stopped, the proportion being of the form, one driver stopped to each 'n' drivers not stopped. At each point a policeman was present to stop the drivers who were to be questioned, and he also did the sampling, stopping one vehicle after he had allowed each 'n' vehicles to run past the survey point.

At each survey point the carriageway was divided by temporary white lines into a questioning lane, a passing lane, and an opposing traffic lane. The questioning lane had to be at least 9 ft. wide, to allow for an 8 ft. 6 in. wide vehicle to be stopped in it. The outer edge of the questioning lane was marked by watchmen's flags, tar barrels, rubber cones, etc. to give protection to the enumerators, who had to stand on the offside of the stopped vehicles for questioning. With all but the most heavily trafficked roads, the chance of two very wide vehicles reaching the census point simultaneously is small, and it was possible to use sampling where the carriageway had a total width just under 27 ft.

The sampling fraction adopted in a survey depends upon the chance of error and the amount of error which is thought reasonable. If a useful saving in work is obtained, a considerable error will always be theoretically possible. If out of 10,000 drivers 5,000 are questioned, and 5,000 only of the total could use the motorway, it is possible for none of the possible motorway users to be included in the 5,000 questioned. But the probability of such a thing occurring is infinitesimally small, and can be ignored. By using the Binomial Theorem, the probability of getting any given maximum level of errof can be forecast as once in so many days in which the survey is taken.

For a motorway survey the level of error is reduced by the fact that the sum of the results for a number of different points and days is obtained, and the errors tend to cancel out. If for a single point an error of p per cent can be expected once in every d days, an error of $\sqrt{\frac{p}{n}}$ per cent is equally likely in the totals of the results for n points.

For censuses it has been found that the variations in the numbers of vehicles from day to day is generally of the order of 5 per cent. It seemed useless to try to obtain a much better degree of accuracy than this, and the sampling fraction was chosen to give a greater error than 5 per cent not more than once in every 100 days. It was practically certain that the overall error would be less than this. The sampling fractions adopted were:

Total 16 hour daily traffic	*Sample fraction*
Less than 3,000 v.p.d.	All questioned
Between 3,000 and 4,000 v.p.d.	One questioned out of each 2 drivers
Between 4,000 and 6,000 v.p.d.	One questioned out of each 3 drivers
Between 6,000 and 8,000 v.p.d.	One questioned out of each 4 drivers
Between 8,000 and 10,000 v.p.d.	One questioned out of each 5 drivers
Between 10,000 and 13,000 v.p.d.	One questioned out of each 6 drivers
Over 13,000 v.p.d.	One questioned out of each 8 drivers

Analysis

For analysis, the country was divided into areas, into which the origins and destinations of vehicles stopped were classified. Large areas were used for distant origins and destinations. A finer division was made for the nearer areas, to give the break up of short-distance traffic: this break up was likely to be required for assessment of the need for junctions and junction design. Different area divisions were used for the three screens, as local traffic at the Preston screen was long-distance traffic for the North of A5 screen, and vice versa. Thus, for the Preston screen the whole of Scotland was regarded as one area, and Lancashire was split into seven areas northwards and 11 southwards, while for the North of A5 screen Scotland was again regarded as one area, while Lancashire was divided into three only. Subdivision north of the Mersey and Preston screens for the southern screen, and similarly for the Preston screen, was needed only as a check on the volumes of through traffic passing through more than one screen.

Two sets of tables were prepared for each point showing the average daily traffic going between these areas in passenger car units. The average daily traffic was calculated from the estimated total traffic for the week by taking five times the Friday traffic, adding the Saturday and Sunday traffic, and dividing the total by seven. One table was compiled for the details given by drivers of their last and next place of call, ignoring the origin and destination, unless there was no intermediate call. This table was prepared on the assumption that the order of calls en route could not be altered, even though the origin and destination of the journey were convenient to the motorway, while the intermediate stops were not. The second table out of each pair was compiled using the origin or last place of call, and the destination or the next place of call, whichever was the more convenient to the motorway. A typical table is shown in Fig. 2 below for a point in the northern screen.

The actual traffic volumes of potential motorway users lay between the volumes shown in the two tables. In analysis the mean of the two distributions was taken. Traffic had been questioned, travelling in one direction only, for each screen. To obtain the both-way traffic this mean value had to be doubled: hence the mean both-way traffic was the total of the two tables. In practice, the difference between the volumes in the two tables was not greater than 8 per cent, and in most cases less than 5 per cent.

The next operation was to determine the percentage of traffic likely to turn over to the motorway. No information was available in this country from which this could be obtained, but American data indicated that traffic turns over to an expressway according to the ratio of the time taken on the shortest existing

BIRMINGHAM—PRESTON MOTORWAY

ORIGIN & DESTINATION SURVEY: AUGUST 1956

Point No. 4

DESTINATIONS / ORIGINS	Preston Area	Lancaster Area	Blackpool Area	Blackburn & Burnley	West Riding	West Riding N.E. Area	North Riding West Area	East Riding and East Area N. Riding	North East England	Cumberland Westmorland	Scotland	Southport Area	Chorley Area	Total
East Anglia	5	2	6	1						4	5			23
South East England	2	1	6	1					3	3	2		1	19
London & Middx.	8	1	18	5						4	7		4	47
Southern England	2	1	2	2						1	7			15
South West England			2	2	1						1		1	7
Severn Valley	1		2	4							1	3	1	12
South Wales	1			5	2						1			9
N. & Central Wales	1		2	12	2	1			3				1	22
S. & E. Midlands	15	8	35	2						8	3		6	77
West Midlands	11	4	13	17						10	6		3	64
East Midlands														
Lincolnshire	5	1	10										1	17
West Riding	29	12	97							5		7	15	165
North Derbyshire	5	1	16	3						2			1	28
South Derbyshire	11	5	29	1						8	7		4	65
Cheshire: Wirral	2		1	2									1	6
Chester Area	46	23	125	17						28	15	3	19	276
Manchester Area	405	194	767	83	2	1			2	151	131	44	135	1,855
Warrington Area	5	3	10	13		1					2		10	44
Central Lancs.	5	1	2	34					1	1	3		24	71
Liverpool Area	8		1	12			1		1				21	44
Bury, Rochdale	53	18	48	1	1					1	1	88	27	238
Bolton Area	481	264	806	76	4	7		5	6	106	40	397	649	2,841
Wigan Area	79	13	21	105	6	1		1	3		7	2	154	392
Southport Area	3			1		1							1	6
Chorley Area	23	3	13	6				1				2	88	136
Total	1,206	555	2,032	345	18	12	1	7	19	332	239	546	1,167	6,479

Fig. 2. Typical sample census sheet.

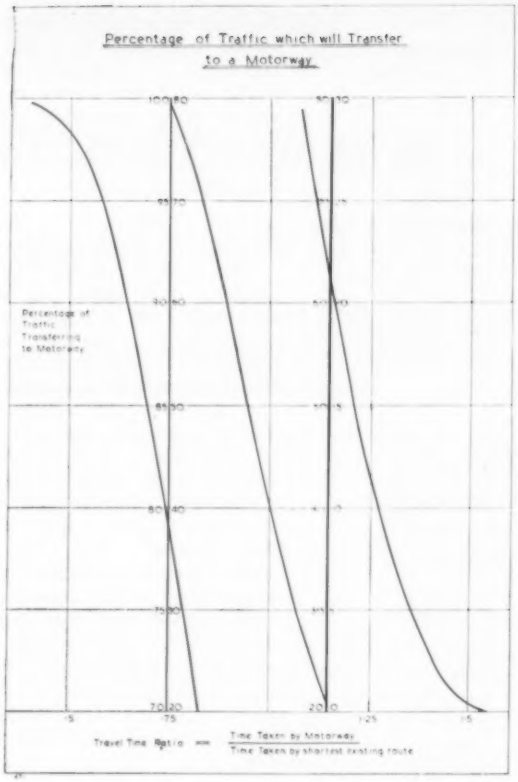

Percentage of Traffic which will Transfer to a Motorway
Percentage of Traffic Transferring to Motorway
Travel Time Ratio = Time Taken by Motorway / Time Taken by shortest existing route

Fig. 3.

route to the time taken using the motorway. Fig. 3 shows the relationship between this ratio and the percentage turnover to the motorway. It was found more valuable to use this in the tabular form, shown in Table II.

For each area, a 'centre of gravity' town was taken, and the time taken over the existing routes between these towns, the times taken between each town and the motorway, and the times taken on the motorway were estimated. A table of percentages diverted to the motorway was then prepared, and using these percentages, traffic which might use the motorway at each screen was calculated. Fig. 4 shows the break up of traffic at the central screen.

The last stage of analysis was to relate the diagrams obtained for the three screens, to obtain the overall distribution of traffic for the whole road shown in Fig. 5.

TABLE II

Time Ratio	Motorway % Usage	Time Ratio	Motorway % Usage	Time Ratio	Motorway % Usage	Time Ratio	Motorway % Usage
0.4	100	0.68	86	0.96	47	1.24	12
0.41	100	0.69	85	0.97	45	1.25	12
0.42	100	0.70	84	0.98	44	1.26	11
0.43	100	0.71	83	0.99	42	1.27	10
0.44	99	0.72	82	1.00	40	1.28	9
0.45	99	0.73	81	1.01	38	1.29	9
0.46	99	0.74	80	1.02	37	1.30	8
0.47	99	0.75	79	1.03	36	1.31	7
0.48	98	0.76	78	1.04	34	1.32	7
0.49	98	0.77	77	1.05	32	1.33	6
0.50	98	0.78	76	1.06	31	1.34	6
0.51	98	0.79	75	1.07	30	1.35	5
0.52	98	0.80	74	1.08	29	1.36	5
0.53	97	0.81	72	1.09	27	1.37	4
0.54	97	0.82	71	1.10	26	1.38	4
0.55	96	0.83	70	1.11	25	1.39	3
0.56	96	0.84	68	1.12	24	1.40	3
0.57	95	0.85	67	1.13	23	1.41	3
0.58	95	0.86	65	1.14	22	1.42	2
0.59	94	0.87	64	1.15	21	1.42	2
0.60	94	0.88	62	1.16	20	1.44	2
0.61	93	0.89	60	1.17	19	1.45	1
0.62	92	0.90	58	1.18	18	1.46	1
0.63	91	0.91	56	1.19	17	1.47	1
0.64	90	0.92	54	1.20	16	1.48	1
0.65	90	0.93	52	1.21	15		—
0.66	89	0.94	50	1.22	14		—
0.67	87	0.95	48	1.23	13		

Comments

The method of using screens for siting the points for a Motorway survey has proved very simple in use, particularly in analysis. More adequate details of traffic between South Cheshire and North Staffordshire would, however, have been given if the screen lines had been closer together.

Two points were sited, one north and one south of Stafford. The results from these showed that short-distance traffic travelling not more than some 30 miles, can all be trapped by a short screen, reaching only a few miles across the line of the motorway. Two such screens, in addition to and lying between the main screens, could advantageously have been added in the present survey. For calculation of the total traffic on the motorway, the positions of points in sub-screens must be chosen so that the results from them can be taken together with those for the outer points in the main screens.

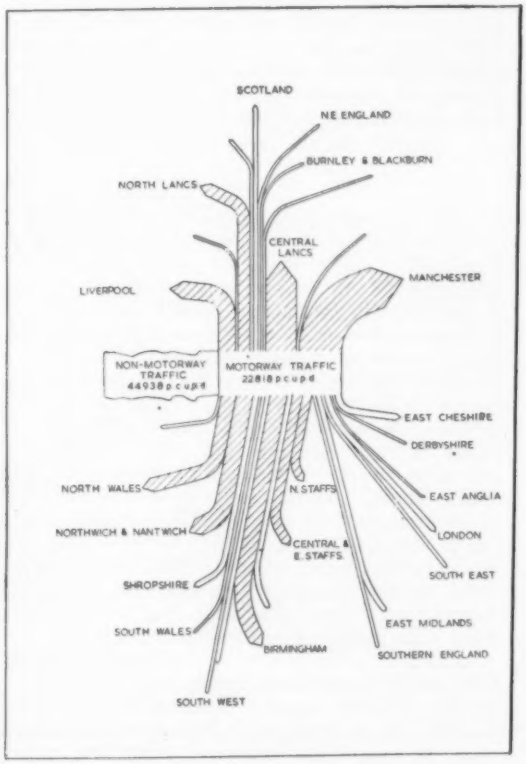


Fig. 4. *Traffic break-down for central census area.*

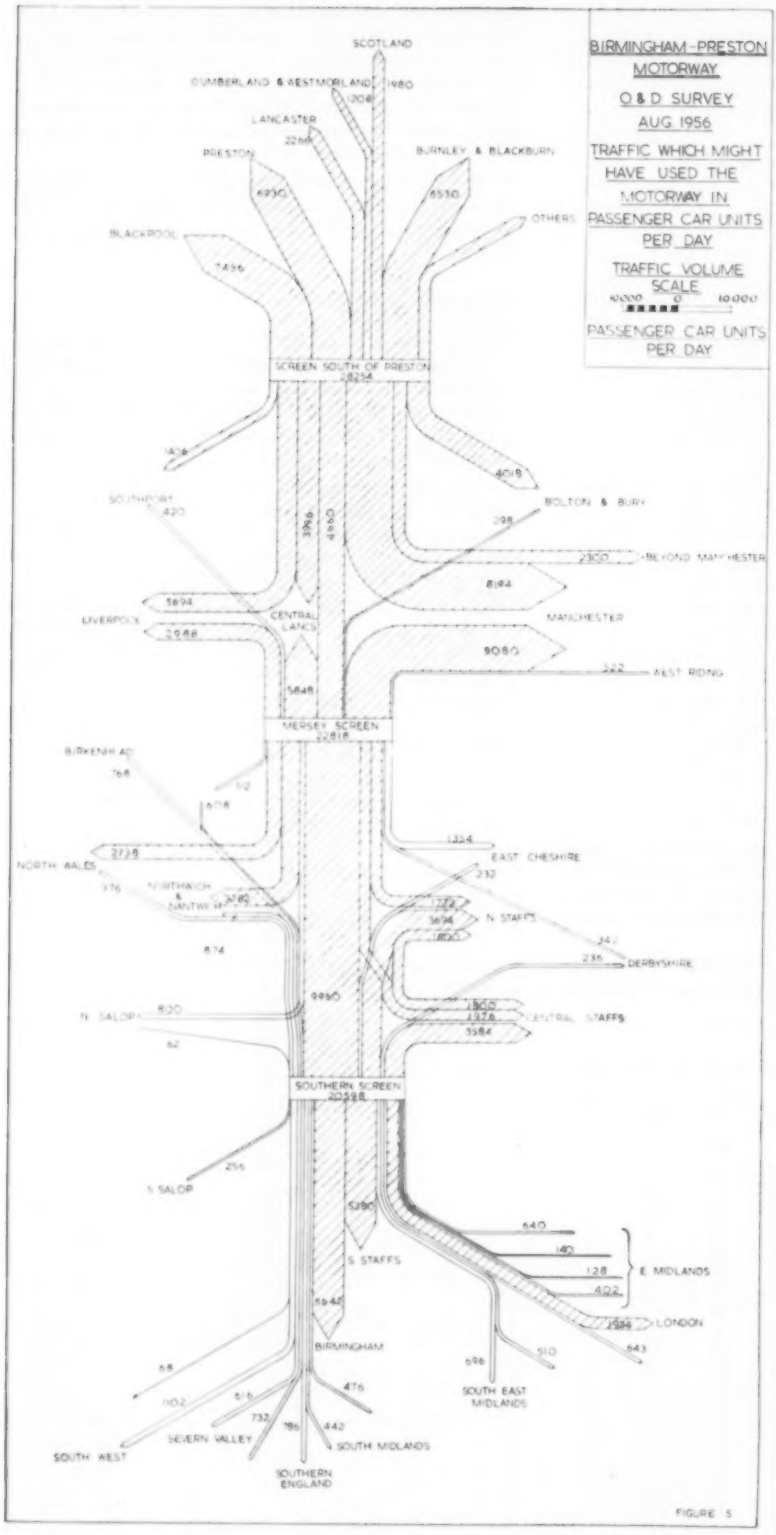


Fig. 5. The final picture showing the break-down by volume and origin and destination of traffic which the survey revealed might have used the motorway had it been available at the time the origin-destination survey was made.

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The screen method of assessing the traffic on a motorway will give a usage slightly on the high side, for some drivers passing through the screen at a distance from the motorway line will not join the motorway until north of the screen, while others will leave it south of the screen. The results show that this effect is small, and it has been ignored. The screen method proved a simple and adequate way of assessing traffic on the motorway. For dealing with similar problems, such as the traffic likely to use an urban motorway, the screen principle of siting the points seems worth consideration.

ACKNOWLEDGMENT

The Divisional Road Engineer, North-Western Division, Ministry of Transport, the County Surveyors of Lancashire, Cheshire, Staffordshire and Shropshire, and the Borough Engineer of Bolton arranged for the field work and preliminary analysis. Their valuable co-operation in this way was largely responsible for the success of the survey.

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NICE CONFERENCE

Special reports of the International Study Week in Traffic Engineering will appear in the November issue.

AMERICAN REPORT

Official Findings on

ROAD AND TRAFFIC SAFETY

By Burton W. Marsh and William L. Carson,
Traffic Engineering and Safety Department,
American Automobile Association

Our American Correspondents give the salient features of the Government report on 'The Federal Role in Highway Engineering' resulting from a three-year study and contribute their comments.

IN the Federal Aid Highway Act of 1956, the Secretary of Commerce of the United States was authorized and directed 'to make full and complete investigation and study for the purpose of determining what action can be taken by the Federal Government to promote the general welfare by increasing highway safety in the United States.' Under this directive, and utilizing the $200,000 provided in Federal funds, a comprehensive three-year study and analysis of highway safety in the United States was carried out by the Department of Commerce Bureau of Public Roads. Mr. Charles W. Prisk of the Bureau, and a former President of the Institute of Traffic Engineers, was directly responsible for the project.

While the principal purpose of the study was to determine appropriate Federal government action to effect improved traffic safety, the findings and data it produced are of value to numerous individuals and organizations having traffic responsibilities and interests in the U.S.A. In the belief that much of the data and information compiled in the study are significant to traffic students in other countries as well, selected findings and conclusions presented in the published report of the study are summarized herein. An attempt has been made to select such information as is pertinent to highway safety in other countries, and of interest to traffic engineers. In almost all instances, material presented here is in a much abbreviated form.

Traffic Accidents in U.S.A.

Explosive growths in the number and use of motor vehicles in the United States have been accompanied by a major highway safety challenge involving a problem much larger and more complex than has been generally realized. In 1959, there were 71.5 million motor vehicles and 84 million licensed drivers in the United States, as compared with 32 million vehicles and 48 million drivers in 1940. Motor vehicles in the United States are driven an average of about 10,000 miles per year, a figure that has varied little during the past two decades.

Approximately 37,800 persons were killed in U.S. motor vehicle accidents in 1959, compared with approximately 34,500 in 1940. The death rate dropped from 11.4 to 5.4 deaths per 100 million vehicle-miles of travel in the same two decades.

Actions and circumstances in U.S. traffic fatalities have changed notably over the years. For example, pedestrian deaths have been reduced more than one-third during the past 25 years in spite of greatly increased traffic. On the other hand, deaths resulting from collisions between motor vehicles have doubled during this period, while deaths from single-vehicle accidents have increased by one-half. At present, more deaths result from single-vehicle accidents than from collisions involving two or more vehicles.

Human Factors

It has commonly been indicated that the driver is responsible for some 90 per cent of highway accidents, with the vehicle or the roadway being cited as a cause in the remaining 10 per cent. Such assignments are of doubtful validity, for the question of the extent of contribution of each of these factors to an accident is involved. Interaction between all three factors creates successful or unsuccessful driving. While the driver is the principal highway safety factor, there is less critical knowledge about him than about either the vehicle or the road. The major gap in traffic safety knowledge in the United States is in the understanding of human factors, though much greater attention is now being given to research in this area. The ways in which the demands of the driving task are adapted to the characteristics of the driver will determine highway transportation safety and efficiency. It is artificial to view human factors as independent of the system in which they must operate.

The consumption of even small amounts of alcohol affects driving practices. Limited accident reports suggest that drinking may be a factor in up to 50 per cent of fatal traffic accidents. The chance of being involved in an accident is about 50 per cent greater for drivers with between 0.05 and 0.1 per cent

alcohol in their blood, compared with drivers having no alcohol, or less than 0.05 per cent alcohol, in their blood.

Increased efforts have been made to improve driver performance by a variety of methods. One of the newer attempts is through adult education classes in driving. Many municipalities now require accident repeaters to attend such classes. Another method for improving driver behaviour is through psychotherapy, on the theory that certain personality characteristics such as aggressiveness and impulsiveness, which have given indication of causing accidents, can be modified through this procedure. Better insight into the basic nature of the driving task and the driver appear necessary before these approaches can be fully effective.

Vehicle Factors

Precise identification of vehicle factors with traffic accidents is particularly difficult, due at least in part to destruction or inaccessibility of the evidence after an accident takes place. To some extent, the vehicle may be regarded as an extension of the driver's capabilities and desires.

It may well be that many accidents attributed to driver error are actually due to the driver's inability to surmount difficulties inherent in his vehicle's design. While many improvements have been made in the safety of motor vehicles (such as improved sturdiness of frames and bodies, better steering and suspension), there remains a need to give more consideration to the safety aspect of certain design features—including bumpers and other projections, features that affect the height of the driver's eye above the roadway, window distortion and fogging, control and instrument placement, and brake cooling. Of particular importance is the need for standardization in the design and placement of lights used to indicate the vehicle's presence and any movement it may be making.

The safety considerations applicable to very light trucks are comparable to those of passenger cars. Larger trucks often have difficulty in maintaining adequate speeds on long up-grades, and this increases the possibility of rear-end collisions. The best approach to this problem would seem to be that of providing an additional traffic lane for trucks in such cases. Trucks also are more subject to 'sideswipe' accidents, and are less manoeuvrable.

Proper vehicle maintenance is essential to improved traffic safety. Studies indicate that defective or inadequate brakes are a major contributor to accidents, while vehicle troubles that disable a car (such as tyre failures, faulty electric systems, steering problems, lack of fuel) also contribute to many accidents. Though the periodic motor vehicle inspection programmes conducted in numerous states help avoid such problems, the major responsibility for proper vehicle maintenance must rest with individual drivers.

Crash Injury Research

At Cornell University Medical College, New York, automotive crash injury research studies have been conducted for several years with the co-operation of physicians, public health authorities, police agencies and others in some 17 states and two cities. Among their findings are the following:

1. Steering assemblies, ejection of occupants from the vehicle, and instrument panels are major causes of injury.
2. In accidents involving 1956 model cars, there were 50 per cent fewer ejections of occupants through car doors than there were in accidents involving 1940-1955 model automobiles. Door latching had been greatly strengthened, at least partially as a result of early crash injury research findings.
3. Users of seat belts had 80 per cent less chance of injury than non-users who were thrown from the car, and 60 per cent less than non-users who remained in the car in a crash.

Studies by the U.S. Air Force have indicated a need for automobile design changes the better to protect vehicle occupants in traffic accidents, including seats that cannot tear loose, steering wheels which are collapsible or present flat surfaces parallel to the thorax, and energy-absorbent coverings on likely impact areas of vehicle interiors.

Highway Design

To provide maximum safety, highways must be designed, within practical limits, to satisfy existing and future patterns of human behaviour and vehicle development. Features deserving attention in this respect include alignment, profile, clearance, horizontal dimensions of the cross-section of the highway, interchanges, traffic controls, and many other details which compose the functional geometry of highway design and operation. In essence, a highway must have the ability to accommodate traffic—this is generally called highway capacity. The elements of design and control that provide efficient, convenient, and economic traffic operation also tend to improve highway safety. A highway cannot be both adequate and unsafe.

Providing highways that will remain adequate for many years is not a simple task. Involved are not only traffic growth but changes in vehicles, variability of driver actions, non-uniformity and changes in traffic laws and enforcement. Yet, public investment in a highway dictates that it serve traffic for a substantial period. Once built, the highway (unlike the vehicle and the highway user) is the one permanent structure of highway safety. Highway hazards that are built in, without sufficient regard for human engineering principles, endure in their effect as persistently as the features that improve highway safety. Changing a design feature after a highway is constructed usually involves considerable expenditure. A large mileage of U.S. primary highways constructed two or three decades ago and still in service, have obsolete design features. Funds and experience were limited, no one foresaw the great surge of road traffic that lay ahead, and quantity in terms of mileage of all-weather roads was more important than quality. Obviously, all highways cannot be totally rebuilt. However, an effective and lasting solution to accident problems on existing highways lies in improving the highway design where the accidents take place.

Leading highway officials also recognized, years ago, the need for modernized highway design standards. Notable among current standards for highway design improvements are those developed by the American Association of State Highway Officials, and approved by the U.S. Secretary of Commerce as criteria for design of the 41,000 miles of the National System of Interstate and Defence Highways. Yet, since this top-ranking system will

carry only about 20 per cent of U.S. traffic, its predicted improvement record in regard to traffic fatalities, will alleviate the accident problem to only a modest degree. Carefully planned annual programmes of reconstruction, rehabilitation, and improvement of the great bulk of remaining highways are very necessary. The AASHO has published design standards for primary and secondary highways, and these are kept current with modern practices. In addition, there have been adopted two comprehensive basic guides entitled: 'A Policy on Geometric Design of Rural Highways', and 'A Policy on Arterial Highways in Urban Areas'. All of these standards and guides are the nurtured product of long experience and research, including countless observations and analyses of performance and driver behaviour, key factors in safe highway design. Examples of design features important to safety are adequate sight distances, and standard practices in the establishment and marking of no-passing zones. Importance of these features is emphasized by trends towards increased vehicular speeds, lower seating of drivers, and the higher accelerative ability of vehicles.

Skidding is a more serious factor in U.S. highway accidents than generally realized. The identification of highway surfaces with poor friction characteristics is extremely desirable. The resurfacing of such highway sections with non-skid materials can then be accomplished, at modest cost, during maintenance operations. Such measures, along with better education of the driver as to skidding problems, should aid considerably the reduction of skidding in accidents.

Rural highways with full control of access have one-third the traffic death rate of those with no access control. Partial control of access is also moderately effective in rural areas, but urban roads with partially controlled access have a worse fatality record than those highways having either full control or no control at all (*See fig. 1*).

The application of traffic engineering principles and techniques to the planning and operation of streets and highways can produce broad benefits in travel time, transport costs, and safety. The planning of new highways should include adequate consideration of the operational and service needs of traffic that will use the facilities, while maximum benefits from existing roads can be achieved through traffic engineering measures such as one-way streets, kerb parking controls, traffic signal synchronization, and pavement markings.

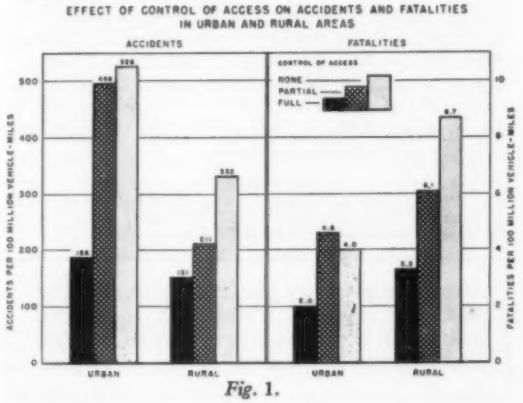


Fig. 1.

As already noted, each of the three constituents of the highway transport system—the driver, the vehicle, and the highway—has certain relationships with highway safety; yet, they are also interrelated.

To determine the relation between driver and vehicle characteristics and traffic accident frequency, operational field studies were conducted by the U.S. Bureau of Public Roads, in co-operation with 11 selected states, on a total of 600 miles of typical main rural highways. About three-quarters of the highway mileage involved had two lanes; the remainder, four lanes. Some 3.7 billion vehicle-miles of travel by 290,000 drivers were covered in the study.

The field studies were supplemented by an analysis of the accidents that occurred on the highways involved during the three to four-year period. A unit of measurement called an 'accident involvement rate' was devised for evaluating this study. An 'accident involvement' is defined as one driver or one vehicle in one accident, while the accident involvement rate is the number of involvements that occur for every 100 million miles of travel.

A preliminary analysis of the results of the Bureau's studies produced the following findings:

1. *Speed.* Drivers travelling at speeds below 40 miles per hour were involved in accidents at a rate several times higher than that of drivers travelling at higher speeds. Daytime involvement rate was lowest for speeds between 55 and 70 miles per hour and increased at higher speeds. The higher the speed, the more severe was the accident. The injury rate was the lowest for speeds of 45 to 70 miles per hour. The injury rate increased sharply for speeds above 75 miles per hour and below 40 miles per hour. (These facts were graphically illustrated in Figures 1 and 2 in the previous report published in *Traffic Engineering and Control*, June 1960, under the title of 'Engineers' Approach to Speed Limits').

2. *Light Conditions.* Accident involvement rates at night were, on an average, twice as high as daytime rates. Yet, night and day speeds were about the same. The ratio of night involvement rates to day involvement rates rose dramatically at the higher speeds. At 50 miles per hour, the night-time involvement rate was more than twice its daytime value; at 70 miles per hour, it was four times as great, thus testifying to the wisdom of lower night-time speeds.

3. *Age of Driver.* Drivers 30 to 60 years of age had the lowest accident involvement rates. Drivers under 20 had the highest rates and were involved in accidents at a rate more than two and a half times that of all drivers. Drivers 20 to 24 years of age and those 65 years and over had rates nearly double the overall average. (*See fig. 2*).

4. *Sex of Driver.* The daytime involvement rate for female drivers was 18 per cent higher than male drivers; the night-time rate, 38 per cent higher. (However, if professional male drivers, known to have good driving records, are excluded from the comparison, men and women had about the same involvement rates).

5. *Age of Car.* Accident involvement rates were uniformly low for passenger cars under three years of age. For older cars, the rate increased steadily with the age of the car—with cars more than ten years of age having an involvement rate nearly two and one-half times as great as that of new cars. (*See fig. 3*).

6. *Horsepower.* Cars with 110 horsepower or less had significantly higher involvement rates than higher powered cars, especially at night. (*See fig. 4*).

7. *Seating Position.* The vehicle driver (left front seat) had a daytime injury rate (number of seat occupants injured per 100 million occupant-miles of travel) of 39, the highest for any vehicle seat position and more than double that for occupants of rear seats. Second highest injury rate was the right front seat position, with a daytime rate of 36.

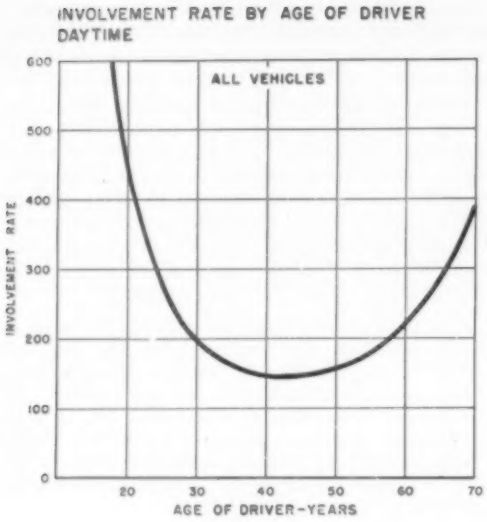


Fig. 2.

8. *Light Conditions and Time of Day.* Darkness per se does not appear to be the chief reason for higher accident and fatality rates during night-time hours. Study data indicate that factors such as fatigue, intoxication, etc. are involved. Fatal accident rates reached a peak between 2 and 4 a.m., but were less than half as high between 9 and 11 p.m.

Road Safety Activities

A chapter in the report is devoted to a review and appraisal of the activities of various governmental, industrial, and civic organizations conducting road safety programmes. It is noted that while Federal activities in road safety seem to have helped increase public interest, improve highway and vehicle design, and have helped as to other accomplishments, the overall effects are not as yet impressive. Most noticeable among the deficiencies is the near-total lack of working liaison among Federal agencies engaged in closely related endeavours.

There is a common tendency to over-generalize with respect to accident causation and to emphasize a single cause. Too frequently, one factor such as speed, alcohol, or accident proneness of drivers, is attacked with neglect of other factors of importance and consequence. An adequate highway safety programme must include a scientific study of the traffic accident as a circumstance in time and space, and in society. Carefully selected representative sample accidents need to be studied and analysed intensively, and this should be done by persons unconnected with practical problems surrounding the accidents.

Stepped-up research holds the most promise for acquisition of the knowledge needed for greater achievements in road safety. Adequate funds, competent personnel, and organization are needed in support of such research. The co-operation that exists among various disciplines on research in other areas is needed in highway safety research.

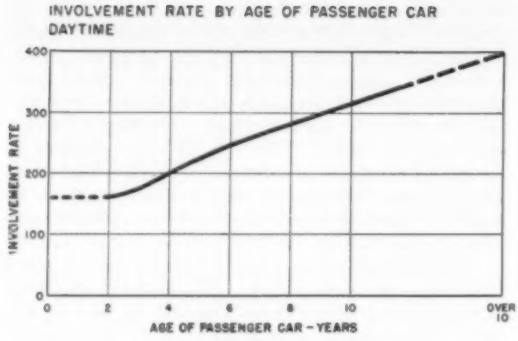


Fig. 3.

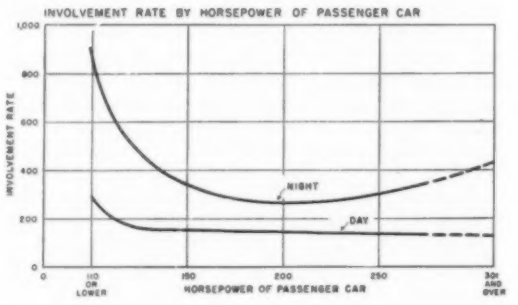


Fig. 4.

Conclusion

The three-year study by the Federal Government has given support and documentation to professional opinions on various aspects of highway safety. However, findings of the study refute some commonly held beliefs as to causes of traffic accidents, and as to proper remedial measures. The report, very importantly, points up the need for increased road safety research, on the results of which broad, well-balanced traffic safety improvement programmes may be based.

The annual multi-billion-dollar traffic accident liability and the interstate character of highway transportation make it logical that the Federal Government accept responsibility for a broad, co-ordinated programme of road safety research. Even a slight reduction in the total traffic accident losses would warrant a considerable research expenditure. A pressing need exists for greater national stimulation of official highway safety efforts. The establishment of an effective national focus for leadership, guidance, and a degree of co-ordination among the many phases of the official road safety effort, is justified by the large accumulating toll of life and property lost in street and highway accidents.

REFERENCE

'The Federal Role in Highway Safety' published by the U.S. Government Printing Office, 1959, 232 pages, self-cover, 18 illustrations. Single copy: 60 cents, 70 cents post free.

Special reports on the International Road Safety Congress, October 3 to 5, will appear in the November issue of 'Traffic Engineering & Control.'

ROAD SAFETY

ROAD CONDITIONS AND ACCIDENTS

by H. Hondermarcq

At the Conference on Road Safety held in Italy earlier this year, M. Hondermarcq, Belgium's Director-General of Roads, presented a paper in which the relative influence of road and traffic conditions and psychological factors on road accidents were considered and some results of an analysis of certain accidents in Belgium were given. These extracts are taken from that paper.

AS a foreword it is desirable to give certain definitions of factors affecting accidents and of their interactions. These factors can be grouped under two headings.

(1) Technical Factors:

(a) *Road characteristics:* it is necessary to include in this general term the characteristics of particular points, such as intersections, level crossings, etc. Certain characteristics, such as alignments, typical transverse cross sections, the nature of a road, are more or less permanent during certain times. Others, such as the adherent quality of the road surface, vary with atmospheric conditions.

(b) *Traffic characteristics:* its volume, the make-up of vehicles of different categories and their speed.

(c) *Conditional characteristics of vehicles.*

(d) *Lighting conditions:* visibility in relation to the time of day or night.

(e) *Atmospheric conditions:* according to whether the weather is dry or there is rain, fog, snow or hail.

(2) Psychological Factors

These concern the behaviour of drivers in the movement of traffic conditions and of their own physical and mental condition.

The effect of technical and psychological factors are essentially different. The distinction is fundamental for the scientific study of accidents as for the conception and the application of measures destined to prevent them.

Technical factors play a dominant role in the possibilities of accidents and in their consequences. The human factor, on the contrary, permanently intervenes in the genesis of accidents. In reality, it is ignorance, the lack of attention, prudence or consciousness which is the initial cause of almost all accidents.

To understand this distinction it is sufficient to refer to a simple example. Let us imagine a collision against a tree of a vehicle, which, travelling at high speed, skids while braking. Speed, which results from the free will of the driver, in this case was incompatible with the capabilities of the vehicle's normal braking power and was therefore the first cause of the accident; but the vehicle, on which the tyres were perhaps worn or the braking system deficient, the carriageway, on which rain may have diminished the efficiency of adherence, and the presence of the tree, are the circumstances which make the collision possible and, in effect, happen. Will it not be quite arbitrary, in this case, partially to ascribe the responsibility of the accident to each one of these factors; the driver, the vehicle and the road? The human and the technical factors are not of the same nature and therefore do not add up.

It is not necessary to develop further the analyses of accidents to understand that the classification of the causes of accidents does not justify a choice between psychological and technical factors. To do so is senseless and of no practical utility in research into safety precautions. The statistics established in this way—and they are still unhappily frequent—are not only wrong in their conception, but they introduce confusion into real appreciation of the nature of accidents and into the importance of the primary causes and of the circumstances which accompany the accidents.

The only method for the scientific study of accidents consists of collecting and collating all relevant information, which may be of a technical or a psychological nature, and to analyse the frequency of accidents in the light of this information. The resulting conclusions naturally imply the need for the application of measures in different ways.

Measures of a technical character referring to road and vehicle characteristics, and to their utilization, can only exercise their influence on the possibilities and consequences of accidents. But measures of a psychological character may be of a repressive or an educative nature, while exercising their influence on the behaviour of the driver, may react on the human and real causes of the accidents.

The theses which tend to base road safety on the human factor by minimizing the importance of the technical factors or, alternatively, while accepting necessity for the improvement of the technical

factors, hold as secondary control and improvement of the human factor, must inevitably be ineffectual. Accidents must be prevented by the human element together with that of the technical.

Psychological action is, nevertheless, indispensable from the general point of view, like all education which teaches the behaviour of man in contact with his equals, and which is the foundation of social life. To deny the necessity for, and the role of education from the point of view of the use of public amenities would be the equivalent of denying it in all conditions in which human relations are established. But psychological action is slow and of a variable efficiency. Its whole effect can only be anticipated after a long period of time by appropriate education and instruction, starting in the primary school.

The necessary disassociation of the technical and psychological factors from the point of view of the nature of their influence on accidents cannot, however, deny their interaction. The psychological factors are not, in effect, independent of the technical ones; the behaviour of the driver results from road conditions, atmospheric and lighting conditions, the volume and composition of traffic and vehicle characteristics.

Paradoxes of Road Safety

Study of the influence of technical factors must, therefore, necessarily show itself by the behaviour of drivers on the road. One such study presumes, generally and implicitly, average behaviour on the part of the driver. This notion is not absolutely valid. It presumes equally a permanent relationship in the time that must inevitably elapse between the accident and the study of the relevant technical factors. It is necessary in this respect to be extremely prudent because conclusions, which appear to be beyond dispute at the time, are sometimes made invalid by facts revealed later.

These are the paradoxes of road safety, well known to people who have had such experience in its problems. Each one knows, for example, that on certain reputedly dangerous roads, or in difficult traffic conditions, because, for instance, of winding curves, or the bad quality of the carriageway, there may be, because of the traffic volume, relatively fewer accidents than on modern roads technically more perfect.

It is proven, on the other hand, that the human factor can in certain cases annul the efficiency of technical improvements by the tendency of some drivers to abuse the more favourable traffic conditions created by these improvements, namely by excessive speed. This proves, if it were still necessary, but it is a truth that must be repeated ceaselessly, the necessity for a prescribed and educative action, judiciously combined with technical improvement in road and traffic conditions. This shows also that the choice of technical factors must be made by observation and inspection on a great number of roads during a period of several years, in order to eliminate from the conclusions the influence of uncertain factors or of chance, which by definition cannot be influenced or modified, and which can lead to a wrong statistical interpretation or to conclusions being drawn from insufficient data.

The systematic study of the influence of technical factors on the roads was undertaken three years ago in Belgium, and simultaneously in different countries, by members of l'Association Internationale Permanente des Congrès de la Route. The principal method of analysis is the following:

A certain number of roads in Belgium, totalling 1,310 km., have been selected and divided into homogeneous sections—that is to say possessing predetermined characteristics—of which a preliminary choice was made following criteria based on their possible or known influence on accidents. These sections comprised two categories: normal sections and those coming under the heading of special conditions. These latter might correspond, for instance, to the existence of an intersection on the same level, a bottle-neck or a badly lighted curve with very bad visibility.

The objectives of the study were the determination of the accident rate per vehicle/kilometer in each homogeneous section, and by vehicles at particular points, and at exit points, and the analysis and comparison of accident rates, in order to prove the influence of each characteristic, and to deduce from this the predictable standard of safety.

It is not necessary to dwell here on the operational technique used, but merely to state that the collection of the necessary information was by issuing a questionnaire both for the homogeneous sections and for the special conditions. This information was codified and filed on perforated cards for mechanical sorting to obtain comparisons of accident rates relative to types of accident for the whole of a group with the same road characteristics, with that of the average, and to determine the difference in these rates. Thus, for the year 1955, 7,881 cards were grouped in this way, independently of the cards necessary for interim calculations. The complete results of this study have not yet been established but some of them appear to be sufficiently interesting to mention in order to reach certain conclusions as to the relative importance of diverse technical road factors and the choice of road characteristics most favourable to safety.

Results

The average rates for each of the routes taken are indicated in Fig. 1. Although it is a question of average rates, relatively important and significant differences exist, which can be attributed to the average characteristics of these routes. The extent of the variation comprises the average rate of 1.246 by 10^6 on road No. 72 and 4.860 by 10^6 on road No. 31.

In regard to the influence of the number of lanes, Fig. 2 indicates the number of accidents per road category according to the number of lanes as well as accident rates.

These rates do not present any significant difference, which in Belgium confirms the opinion occasionally held that three-lane roads are more dangerous than two-lane roads, the daily average volume being 3,300 vehicles on two-lane roads and 6,350 vehicles on three-lane roads.

The accident rates on two and three-lane roads are influenced in a different way by regional topography. A superficial examination of statistics would point to the conclusion that three lanes are more dangerous in Basse Belgium (flat land), that is to say with good visibility, than in Moyen Belgium (valley land) with poorer visibility, and this is contrary to that which is

FIG. 1
Average accident rate on homogeneous sections of the most important arterial roads in Belgium—1955

Journey		Veh. x km.	No. of accidents	Accident Rate A/10^6 Vehicles	
Route No.	Section			Sections	Total Journey
No. 1	Brabant.	14,370,766	70	4.871	2.634
	Anvers.	105,963,105	247	2.331	
No. 1 bis	Brabant.	61,759,729	73	1.182	1.341
	Anvers.	94,809,689	137	1.445	
No. 2	Brabant.	108,180,301	324	2.995	2.995
No. 3	Brabant.	86,578,581	249	2.876	3.155
	Limbourg	29,491,275	120	4.069	
	Liege.	33,528,646	103	3.072	
No. 4	Brabant.	42,084,168	231	5.489	3.461
	Namur.	72,075,209	207	2.872	
	Luxemb.	64,111,748	179	2.792	
No. 5	Brabant.	75,033,201	226	3.012	3.052
	Hainaut.	19,656,786	63	3.205	
No. 7	Brabant.	76,550,052	221	2.887	3.274
	Hainaut.	41,332,665	165	3.992	
No. 8	Brabant.	14,677,728	46	3.134	2.982
	Hainaut.	66,146,540	195	2.948	
No. 9	Brabant.	21,116,139	126	5.967	3.822
	Flan. Or.	32,069,971	110	3.430	
	Flan. Occ.	59,578,368	195	3.273	
No. 10	Brabant.	99,863,574	366	3.665	3.429
	Flan. Or.	128,118,867	457	3.567	
	Flan. Occ.	32,152,842	69	2.146	
No. 14	Anvers.	70,905,459	213	3.004	3.186
	Flan. Or.	152,098,454	482	3.169	
	Flan. Occ.	30,639,913	113	3.688	
No. 15	Liege.	13,031,161	46	3.530	2.722
	Luxemb.	17,461,067	37	2.119	
No. 17	Liege.	27,526,543	140	5.086	4.182
	Namur.	53,056,827	197	3.713	
No. 22	Hainaut.	87,174,806	382	4.382	4.382
No. 31	Liege.	32,304,527	157	4.860	**4.860**
No. 32	Liege.	20,559,680	72	3.502	3.502
No. 49	Brabant.	13,197,361	22	1.667	2.376
	Namur.	23,843,931	66	2.768	
No. 51	Brabant.	35,499,398	118	3.324	3.324
No. 61	Hainaut.	28,423,773	88	3.096	3.096
No. 62	Flan. Or.	8,695,652	20	2.300	2.300
No. 65	Flan. Occ.	21,842,355	69	3.159	3.159
No. 68	Flan. Or.	14,080,966	56	3.977	3.977
No. 71	Hainaut.	3,214,056	15	4.667	2.916
	Flan. Occ.	67,772,679	192	2.833	
No. 72	Flan. Occ.	70,626,003	88	1.246	**1.246**
No. 296	Flan. Occ.	17,654,477	28	1.586	1.586

FIG. 2
Accident rate by No. of lanes

No. of lanes	No. of accidents	Vehicle/ Kilometers	Accidents 10^6veh. x km.
2	2,934	910,356,040	3.22
3	3,400	1,062,806,350	3.20
4	298	88,408,500	3.37

stated for two-lane roads. But this irregularity is only apparent because the majority of three-lane roads are transformed by similar markings, as two-lane roads with dangerous spots, notably at curves, intersections, crowns, level crossings, etc. On these spots the roads in question consequently have the characteristics of two-lane roads, but are wider and offer, therefore, greater safety than two-lane roads of normal width.

The most influential technical factor, from the point of view of accidents, is indisputably the directional separation of traffic. The comparison of accident rates on ordinary roads and on motorways is convincingly significant in this respect.

The number of unexpected accidents in 1955, 1956 and 1957 on the Bruxelles-Ostend motorway are shown in Fig. 3. If one compares the corresponding rates to that of the average rate on ordinary rural roads, where it may reach 3,065, one sees that on the latter this rate is nearly 2.5 times higher.

FIG. 3
Accident rate—Brussels-Ostend Motorway

Year	No. of Accidents	Vehicle/ Kilometers	Accidents 10^6veh. x km.
1955	181	141,387,535	1.28
1956	261	223,590,575	1.167
1957	269	253,101,125	1.063
1958	407	302,151,209	1.347
TOTAL	1,118	920,230,444	1.215

The comparison of accidents on the motorway with that of the ordinary road, Route No. 10, in Fig. 4, confirms the manifest superiority of the motorway, since in this case the rate is 2.7 times higher.

FIG. 4
Accident rate: Route No. 10, Brussels-Ghent-Bruges

Province	No. of accidents	Vehicle/ kilometers	Accidents 10^6veh. x km.
Brabant	366	99,862,590	3.665
Fland.Orient.	457	128,091,070	3.568
Fland.Occid.	69	32,552,250	3.120
Route No. 10	892	260,505,910	3.429

The important reduction in accidents on motorways by comparison to the ordinary road is not due exclusively to the separation of traffic direction. It is equally due to the elimination of intersections at grade. The statistical study of the distribution of accidents on the motorway shows that the accident rate is two to three times higher in the neighbourhood of intersections than between them, which shows that, despite slower and faster traffic lanes and despite the organization of traffic streams simply converging or diverging, the accident rate is not perceptibly lower than that registered on ordinary roads. This establishes that intersections at the same level are, in fact, the vulnerable points for road traffic.

FIG. 5
Accident Rate by Type of Road Surface

	CONCRETE			TOTAL
No. of Lanes	2	3	4	
Length Surveyed (Km.)	165,173	267,988	8,400	441,561
Vehicle-kilometres	201,893,530	703,164,560	24,332,220	929,390,310
No. of Accidents	597	2,131	25	2,753
Average rate	2,957	3,300	1,027	2,962

	BITUMINOUS			TOTAL
No. of Lanes	2	3	4	
Length Surveyed (Km.)	349,621	125,876	5,248	480,745
Vehicle-kilometres	317,548,540	221,085,950	25,192,020	563,826,510
No. of Accidents	861	642	82	1,585
Average rate	2,711	2,903	3,254	2,811

	STONED PAVEMENT			TOTAL
No. of Lanes	2	3	4	
Length Surveyed (Km.)	246,847	64,411	17,102	328,360
Vehicle-kilometres	390,913,970	138,555,840	38,884,260	568,354,070
No. of Accidents	1,476	627	191	2,294
Average rate	3,775	4,525	4,912	4,036

Another factor is the nature of the surface. In classifying sections by the type of surface and number of lanes, one can appreciate the influence of these two characteristics and their eventual effect on accident rates. Fig. 5 relates to accidents on different surfaces.

The average rate of 4,036 for badly paved roads is nearly 50 per cent higher than the average on other surfaces. It is a question, in general, of old paving in which the co-efficient slipperiness is definitely lower than that of modern surfaces. The question of adherence in driving and braking is of fundamental importance to road safety. It has caused the Belgian Government to impose rules which were previously totally absent from the required specifications.

next month's contributors include:

Parking Meter Facilities
J. T. Duff
Senior Engineer, Ministry of Transport

Traffic Congestion and London's Buses
A. T. Wilford
Director of Research, London Transport Executive

American View of Traffic Engineering
Edward G. Wetzel
President Institute of Transport

Berlin's Urban Motorways
Dip. Ing. W. Liepold
City Engineer, Berlin

Instruments for Traffic Engineers 2
Volume and Speed
F. D. Hobbs
Paviors Lecturer in Highway and Traffic Engineering

and

special reports on:

AASHO Road Test of the Highway Research Board (U.S.A.)

Progress in Road Construction in West Riding

Association of Public Lighting Engineers Conference

PROFILE . . .

of a

TRAFFIC ENGINEER

J. F. A. BAKER

THE terse items in *Who's Who* about J. F. A. Baker do not mention the M1, although, as Chief Engineer to the Ministry of Transport (Highways), he has possibly, apart from the Minister, had as great a personal responsibility for it as anybody in the country. Just the same, the entry provides unusually good keys to the career behind it. At a glance it seems conventional enough . . . the professional qualifications, experience with local authorities, then regional posts with the Ministry. London was reached, as Deputy Chief Engineer in 1953, and a year later came promotion to Chief Engineer (Highways). There are the expected connections with national and international organizations, mention of his club, and of his hobbies, one of which is sailing.

Local authority, central authority, the conference table and sport: these four things have not come accidentally together. To start with, family traditions in public service and in sport, leading to a love of open air life, were a small but definite, influence in choosing a career. Baker was intended for the Navy, but his eyesight was not good enough. With mathematics as one of his better subjects at school, engineering was an obvious alternative. It also occurred to the boy that surveys would be done out of doors.

It was not unnatural that, on qualifying, he would find a job with a local authority. Nor that his gifts should advance him; though it was not necessarily to be foreseen that he would reach the eminence of responsibility for carrying out the country's whole road programme. Very early on, however, family tradition was again playing its part. His grandfather, a keen sailor, was a county alderman for many years. Baker's father, and an uncle, were Town Clerks. He, himself, when still not twenty-six, gave up what were admittedly, not yet considerable pension prospects, but took a lower salary to join the Ministry. Roads had 'got him'. He foresaw the increase of cars and the importance of road development; and, through the years, road work has been for him an unflinching dedication.

'Allan' Baker, as he is known in his own circle, got his training the hard way. Born at Hounslow, Middlesex, in 1903, he was educated at St. Paul's, where, after the inevitable grounding in classics, he moved over to the army and engineering side. Then, after articled pupillage, he served in two other engineers' and surveyors' departments, becoming Deputy Engineer at Southall at a particularly early age. If he did not always welcome being 'kept indoors' to deputise for his chief at Council meetings, he was to be grateful for early responsibility. On joining the Ministry, he was soon grateful for the advantage of knowledge of local government, especially valuable since road work is team work, and good liaison essential in a system in which responsibility for the country's roads is divided between the Minister and local highway authorities. Naturally a lead is often expected from the centre. One such, with Ministerial encouragement, was the setting up in 1956 of a separate Traffic Engineering Branch of the Ministry. Interdependence, anyway, is one of Allan Baker's cardinal beliefs. We all build on what others have done, he maintains, and often our own new contributions are useless without the co-operation of others.

His own experience comes from the heart of the system. For over twenty years he held posts in different regions for the Ministry, years crammed with harder and harder work and more and more responsibility, but with much victory, too, in finding time for sport. Physical exercise and humour are, according to Baker, indispensable for maintaining a clear mind and a sense of proportion. He was still playing rugby football and water-polo when he joined the Department at Exeter; and tennis at Bedford and Nottingham; and at Penarth he was dinghy racing, his daughter, on vacation from Oxford, crewing for him. 'But sailing and chess are the perfect relaxation,' Baker says. 'You can't think of anything else at the same time.'

He must have needed philosophy during the years he calls 'frustrating', before the demand for a vital road programme became insistent, though in the immediate post-war period, when Road Acts already passed by Parliament had to be held over, he was tolerant of the reason—the more desperate need for housing. Now that a start has been made, Baker is so happy, he hardly grudges the greater fight than ever for outside relaxation. With the London-Birmingham Motorway really in existence, Baker speaks like a boy of 'the great fillip, the new lease of life for engineers'. Like a boy, too, he will sweep the table clear of papers, and with matchsticks demonstrate how it was possible to economize in the construction of dual carriageways for the improved trunk road from London to Newcastle by re-using the old roadway. Since one-way traffic would make for greater safety, he decided that, on much of the length, a second carriageway should be provided 'on the other side of the hedge'. Thus the natural amenities could often be preserved. Also a greater mileage of consistently good driving conditions could be achieved than if available funds had been concentrated on 'pepper-potting' expensive improvements at merely the worst spots.

(*Concluded on page 299*)

LETTERS to the EDITOR

HARD SHOULDERS

From Sir William Glanville

Director The Road Research Laboratory

YOUR Editorial in Vol. 2, No. 4, August, 1960, of your Journal, commenting on results of a simple experiment we carried out on the possibilities of a driver getting on and off a lorry parked on a hard shoulder without getting on to the carriageway, is, I think, liable to mislead some of your readers. There was no doubt that the wider the shoulder the easier it was for the driver to dismount away from the carriageway, and of the widths tested 12 feet was the best from this point of view.

This is, however, only one factor to be taken into account in deciding upon the width of a shoulder to use. Increasing the width of a hard shoulder can be costly and the money might be spent better in other ways and possibly save many more accidents than expending it on a very wide shoulder. Further investigations are being carried out on the optimum width of the shoulder and will be reported on in due course.

Approach to Accidents

From J. J. Leeming, M.I.C.E.

Brig. Stoney's description of the industrial approach hammers home my main point, that on railways and industry the primary objective is the prevention of accidents, while on the road it is the punishment of motorists. The whole approach is different. I do not agree that the existing law should be enforced, it should be drastically revised to bring it into line with reason and justice. If I think, as I do, that the law is bad, and a potent factor in causing accidents, then it is my duty to say so.

Mr. Heasman's letter points out another way in which the law may help to cause accidents in his reference to disqualification. If the M.C.C. had decided that one of our players in the recent tests played very badly, and told him to stop playing cricket for a year, the press and country would rise as one man and call them madmen. Yet we are doing that daily to motorists and no-one calls the courts mad. Yet surely the analogy is exact. Both cricket and driving need skill and skill needs practice. Stop practice and you reduce skill. Mr. Heasman's proposal that a driver should be disqualified for life if he failed to pass a second test is preposterous, it would be grossly unjust and might lead to frightful abuses.

NEW PUBLICATIONS

The Assessment of Priority for Road Improvements. Road Research Technical Paper No. 48 by D. J. Reynolds, B.Sc.(Econ.). Published for the D.S.I.R. by H.M.S.O., 2s. 6d. net, by post 2s. 8d., U.S.A. 45 cents.

The Road Research Laboratory has published in this paper a description with full practical details of the method it has developed for assessing the merits of alternative road improvement schemes on the basis of their relative value to the community. Briefly put, the net annual benefits expected to result from road works are expressed as a percentage of capital cost, the resultant rate of return being used as an indication of priority to be accorded to the works. The general method followed is to estimate for traffic five years hence, annual vehicle-mileage, average speed (or delay), and personal-injury accidents before and after the works are carried out. The resultant annual changes in cost of the annual vehicle-mileage run are then calculated, and also the expected annual change in personal-injury accidents is valued. These cost changes are then added, and the net additional maintenance costs resulting from the improvement are deducted, to give the net annual savings which in turn give the required rate of return when expressed as a percentage of the capital cost of the improvement. The value of the paper is enhanced by inclusion of standard forms with detailed instructions for working out rates of return step by step.

If the R.R.L. method is followed by Highway Authorities in determining priorities, and taken into account by the Ministry of Transport in making its authorizations, as it should be, the selection of schemes should at least be measured against an economic yardstick and be determined less by hunch or according to outside pressures.

Fundamentals of Traffic Engineering, 1960 Edition, by Norman Kennedy, James H. Kell, and Wolfgang S. Homburger. Syllabus No. 392, University of California Press. $4.00.

Designed as a syllabus for use in undergraduate courses in traffic engineering at the University of California, these notes include a large amount of material which is otherwise available only in widely scattered publications. The syllabus covers fundamental material in traffic studies and characteristics, traffic operations and devices, and in design planning, and administration. The orientation, of course, is toward United States (and, more specifically, California) problems and practice. However, some of the contents are of general interest to students of traffic engineering elsewhere and will be of particular value to those now studying the subject at the new courses in this country.

Professor Kennedy is Assistant Director, and his co-authors are Assistant Research Engineers, at the Institute of Transportation and Traffic Engineering of the University of California.

A Guide to Engineers In the Making up of Private Streets. Road Research Note No. 26. Published for the D.S.I.R. for H.M.S.O. 1s., 30 cents U.S.A., by post 1s. 2d.

One of the many problems facing local authorities is the making-up of private streets to acceptable standards of construction at a reasonable cost to the frontagers, and in this paper the Road Research Laboratory outlines a number of methods to assist them in their task. Economies recommended are based on the experience of local authorities and can be effected by making the best use of existing construction as well as cheap local materials in new road works. The recommendations given are for roads carrying light traffic of up to forty-five commercial vehicles (of unladen weight exceeding thirty hundredweight) daily.

Car Driving for Beginners. R.A.C. 2s. 6d.

This booklet designed for those taking driving tests deals comprehensively with elementary mechanics of the motor car, road sense, and the test itself. It is amply illustrated.

CONFERENCES

October 6

'The Problem of Car Parking' Day conference organized by Institution of Municipal Engineers at Central Hall, Westminster.

October 18 to 20

The National Safety Congress, Central Hall, Westminster, organized by RoSPA.

INSTRUMENTS FOR TRAFFIC ENGINEERS

The second article in this series by F. D. Hobbs on 'Volume and Speed'

is held over until next month

PLANNING OF STREET LIGHTING

by J. T. Grundy

BEFORE any attempt can reasonably be made to plan the street lighting of any city or town, it is essential to acquire detailed knowledge not only of the layout, surfaces and surroundings of the streets concerned, but also of the tastes and habits of those who use them. On the question of surroundings, moreover, it is advisable to enquire whether there are any pending developments that might materially change them. These facts have been amply demonstrated in the course of numerous investigations into street lighting projects for such widely separated cities as London, Cape Town, Khartoum, Salisbury (Rhodesia), Accra (Ghana), and Melbourne.

Basic Principles

It is generally agreed that recent years have produced steady evolutionary progress in the sphere of outdoor lighting. Nevertheless, large sections of the British Standard Code of Practice CP. 1004, Part 1 of 1952, and Part 2 of 1956, are still applicable today. One desirable revision will probably lie in increasing the mounting heights for both Group A and Group B lighting, in order to provide for the increased efficiency which the lamp technicians have achieved.

There is still no known method of satisfactorily measuring street lighting, and it is to be regarded as an advantage that the B.S. Codes of Practice do not specify such factors as test-point illumination. If such factors are measured, the results should be used only as a guide in maintaining the equipment.

The lighting of streets presents a problem quite different from all other lighting problems. A street system involves not simply lanterns, lamps, poles and auxiliaries which the manufacturer supplies; the road itself, with its carriageways, footpaths, buildings and trees, is to an unusual degree an active part of the lighting system. For an installation to be successful it must be designed in harmony with these extraneous constituents, though they do not themselves come within the control of the lighting engineer. The location of the sources, the mounting height, the distribution of light and the spacing are all interrelated and have to be adapted to the other characteristics of the road and its surroundings.

All street lighting installations are composed of individual lighting units, and the effect of a single unit must be studied before a number of them can be satisfactorily combined into an installation. Whenever such a unit is placed above a road surface, a bright area is formed on the road. The shape and brightness of this area are determined largely by the characteristics of the road surface, the light distribution, the mounting height and the spacing. As a rule the bright area appears roughly T-shaped, the tail of the T being of high brightness and extending always towards the observer. The properties of most road surfaces prevent this bright area from extending appreciably on the far side of the light source, and the dark region nearly below the lamp has to be lighted by adjacent sources (on the same side of the road).

The bright area changes its shape with the distance of the source from the observer, becoming narrower and relatively rather longer as this distance increases. With normal sources its general shape does not change much, and the maximum brightness is always roughly constant, though it is somewhat diminished when the source is very close. The bright area from a distant source can extend surprisingly long distances. It generally appears to end about 30-50 ft. from the observer; thus, a source 500 ft. distant produces a bright area about 450 ft. long, and more distant sources produce even longer bright areas, provided that the lantern concerned emits light in the required directions, i.e. 75° to 87° from the downward vertical.

The effect of a cut-off distribution, in which no light is emitted above 75° from the downward vertical, is well known. For the formation of their tails all the more distant bright areas require light which leaves the source at greater angles than this. Consequently, as the distance from the source increases, the bright area becomes a narrow band stretching across the road without a tail for perspective, the head of the area becoming fore-shortened at greater distances.

Some Experiments

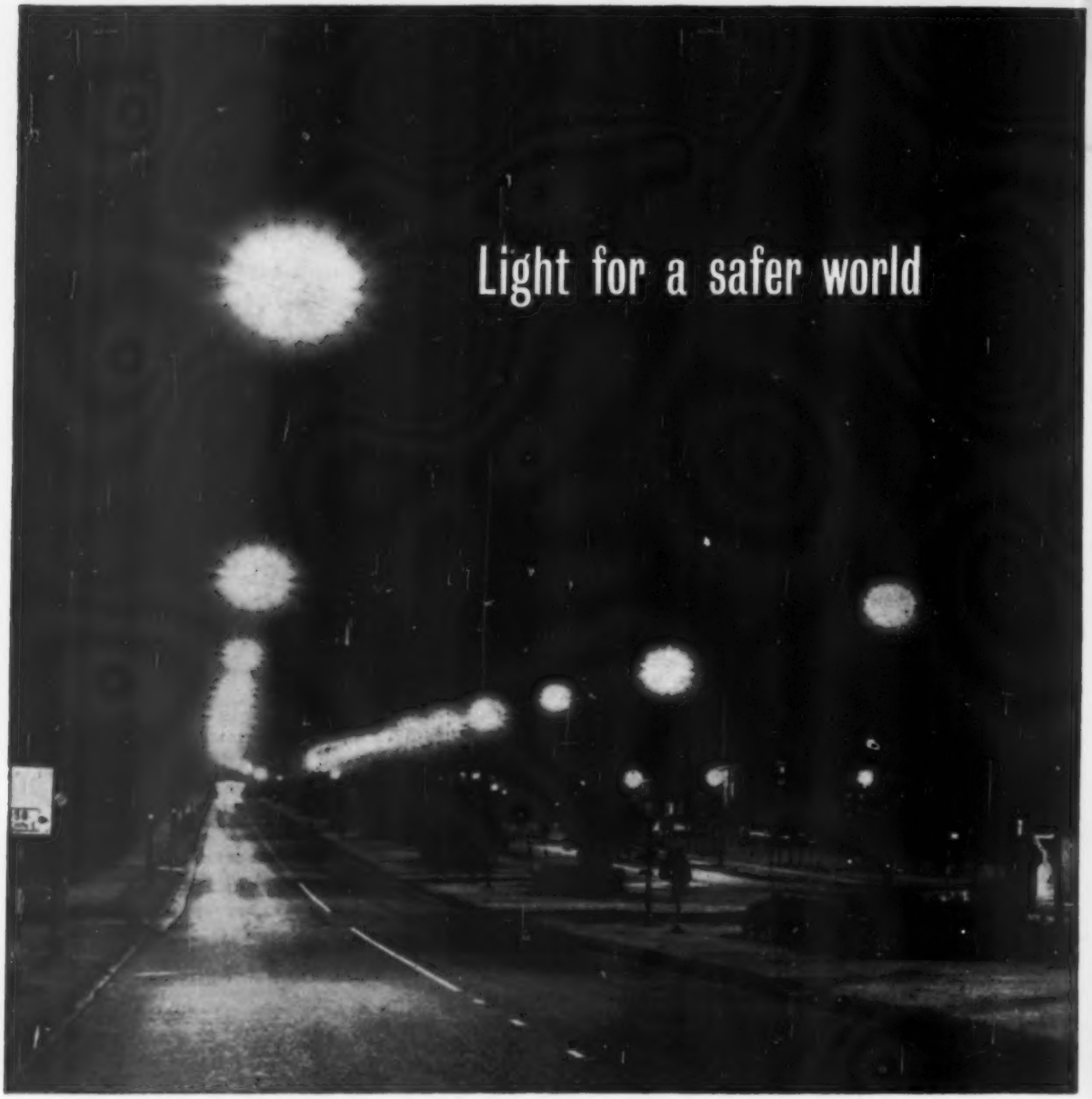
The properties of the single bright area being established, several of them can now be combined into an installation. An experiment in which two bright areas are combined together, much as they are in an actual installation, can be made with various spacings. If the sources are well separated, a dark region appears between the two light areas. In an actual installation such dark regions are unpleasing and may be dangerous. As the distance apart of the sources is reduced, this dark region becomes innocuous and with close spacing it vanishes. Experiments of this kind have provided data, with the help of which the siting of light sources can be carried out with precision. When the road bends or changes direction, the siting of the sources becomes critical, and for a satisfactory result the normal staggered arrangement must in such places be abandoned in favour of a carefully planned angular arrangement.

Siting of Sources

Sources are generally placed at the sides of the road, since this arrangement best shows up the kerbs and junctions as well as any obstructions such as pedestrians stepping off the kerb. On wide roads this advantage is in some measure offset by the tendency to a darker centre of the road, though generally speaking the centre is less important than the sides. This effect can, however, be counteracted by using occasional central sources. An experimental installation using central sources at every third post and set up on a carriageway of moderate width clearly showed the advantage of such an arrangement of sources. This experiment also served to show the effect of wetting the surface. As the surface became wet, the bright areas became much thinner, brighter and longer, and the regions between appeared much darker by contrast until the road seemed to be covered by black and white streaks. It is very difficult to make a really flooded road surface appear evenly lighted, but if the basic principles are followed, the results in the wet will be as good as is possible with a practicable installation.

One problem occupying the minds of lighting engineers today is reverse silhouette effect and glare. The accepted principle of British street lighting is silhouette vision, viz. objects are seen as dark objects on a light background. To produce the necessary road brightness effect, the engineer depends on light emitted at high angles, but with the modern skid-reducing road surfaces and the increased use of colour for cars this effect is becoming more difficult to produce. One method is to increase the mounting height from 25 ft. to 30 ft.

It is generally agreed that a longer linear source such as a fluorescent tube gives a broader streak of brightness than other types, and this is particularly



With road safety a major consideration, this ¾-mile stretch on the main Glasgow-Edinburgh road is now lit by 52 high wattage Sodium lamps developed by Philips Electrical Ltd. The new system was largely the inspiration of Mr. Denis Colvin, City Lighting Engineer to the Glasgow Corporation, who co-ordinated the activities of Philips on lamps and gear, the Engineering & Lighting Equipment Co. Ltd. in their development of the new ELECO Golden Ray '280', and of Messrs. Stewarts and Lloyds, who provided the special steel columns. In operation it is no longer possible for confusion of light sources to be an accident hazard and the reduction of the number of columns used reduces the number of possible collision points.

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so in wet weather. It should be borne in mind, however, that fluorescent light sources do not entirely enable the spacing angles to be widened on bends. Moreover, the practice of placing a light source opposite a T junction with a view to providing a streak of brightness stretching towards the motorist entering from the T junction is not altogether applicable when using fluorescent lanterns. This is due to the fact that very little light is emitted from the end of such a lantern. Experiments are, however, in progress to determine the effect of tilting such lanterns for this and other purposes, since with a tilt of, say, 15° more light will obviously be thrown across the road and thus down a T-junction road.

Surveys

Every engineer is well aware that before a suitable lighting scheme can be produced, it is essential to make a detailed survey of the roads concerned, including enquiry into the existence of underground cables, drains, gas mains and other concealed obstructions. When the layout is being checked, the traffic flow should be watched and special attention paid to one-way arrangements, pedestrian crossings, roundabouts and the like. The surroundings should also be noted with a view to taking advantage of any existing light backgrounds.

Where the pavements are narrow, it is preferable to site a pole opposite a dividing wall rather than in front of a shop window or a doorway; and such possible obstructions as sun-blinds and signs should be borne in mind, since it is normal practice for the pole to be set back 18 in. from the edge of the kerb. With railways or docks in the vicinity, attention must be given to preventing interference with railway signals or the movements of ships. The provision of rafts and/or cranked roots may be necessary, where there is insufficient ground for the normal root.

Should the scheme be likely to entail the use of span wires, the suitability of the buildings or existing poles for supporting the load will have to be examined, bearing in mind not only the weight of the lanterns, but also the prevailing wind and weather. Tree-lined roads present a problem, and it will have to be decided whether the lopping of the trees will suffice or whether central suspension will have to be provided.

Having given attention to all the factors mentioned above, the engineer will be in a position to submit plans for a suitable lighting system, at the same time giving an estimate of the improvement to be effected on any system already existing.

Traffic Routes

It is generally considered that incandescent lighting is not the most suitable for main traffic routes, since both the luminous efficiency and the life of the filament lamp compare very unfavourably with those of sodium, mercury or fluorescent lamps. Where the road is divided into two separate carriageways, the use of central double-arm standards may be suggested and consideration given to unidirectional lighting. There are, however, certain objections to both these systems, and the solution is probably opposite side mounting units, 35 ft. to 40 ft. high, spaced 170 ft. to 180 ft. apart. All this is adequately covered in the existing Code of Practice, though a revised edition, when it comes, may well recommend the greater mounting height.

It is well, however, to draw attention here to the trials being carried out by the Road Research Laboratory in an endeavour to provide a cheap system which would be more satisfactory to the motorist than relying entirely on his own headlamps. In November 1956, for instance, a short trial lighting system was erected on the Colnbrook By-pass. The road consists of a single three lane carriageway 30-33 ft. wide. The system employs centrally suspended cut-off lanterns at 90 yard spacing, using 400 watt mercury vapour lamps. It is essential with such a system to reduce glare to a minimum, and for this reason cut-off lanterns were used. Central suspension was chosen to help spread the heads of the bright patches across the full width of the road. Hence despite the alternating dark and bright patches, an object or figure is silhouetted against several bright patches to the approaching motorist.

Town Lighting

It is common knowledge that sodium lighting for towns is no longer considered satisfactory from the point of view of colour rendering. Undoubtedly, the style and character of our towns are changing, and it would seem that the town planners are convinced that certain high streets and town centres are no longer suitable for arterial traffic, but are rather the province of the pedestrian.

Certain suggestions and treatment are proposed for the precincts of St. Paul's in London and also for Basildon New Town. In such circumstances the problem is simply to provide the best form of lighting for pedestrian movement, but there will still remain many towns where through traffic will predominate after the major pedestrian activity has subsided, possibly after 11 p.m., and in such cases the lighting should be specially planned for this type of traffic at the relevant hours.

The principle of stepping up the street lighting for rush-hour traffic is to be commended, and experiments in this regard are now being conducted in Coventry by adding extra tubes in the fluorescent lanterns. It may well be that the ultimate distribution required will prove to be concentrated illumination for rush-hour conditions, and road brightness for the hours when through traffic is the more important consideration. In towns and cities, except for carefully selected one-way streets, there would appear to be little future for unidirectional lighting.

Before turning to Group B lighting, reference should be made to the criticism levelled against 25-ft. standards installed against lower buildings (in such main shopping streets as those in Solihull) and in towns where it is the practice to run bus routes away from the main centres. Nothing is more deplorable than bus routes running through Group B lighting, where Group A lighting is not economically possible. Work on this problem was put in hand, and in co-operation with Mr. H. Carpenter, F.I.E.S., M.I.E.E., Past-President of the Association of Public Lighting Engineers, and the Carpenter Lantern was developed. This lantern incorporates four 3-ft. 30-watt tubes and, departing from the Code of Practice, a mounting height of 20 ft. is recommended for it. Providing the spacing is carefully calculated, it is possible with this lantern to attain the lumen value specified for Group A lighting and its light distribution is such that the results are very satisfactory.

Residential Areas

It has long been recognized that one of the most important problems to be solved is the lighting of residential roads, for the mileage of such roads is some five times that of the traffic routes, and the power and capital available for lighting them is totally inadequate. The methods used hitherto have generally been small-scale imitations of those designed for traffic routes and have not been conspicuously successful.

The Code of Practice, Part 2, 1956, provides for Group B1 and Group B2 lighting. Group B1 is intended to cover roads that have buildings closely fronting them, while Group B2 is for roads containing houses with gardens or forecourts, where a high proportion of the available light has to be directed longitudinally.

The Carpenter lantern previously mentioned can also be used satisfactorily for the illumination of residential roads, since it is available in a type accommodating only two 3-ft. 30-watt lamps. Indeed, a system using such lanterns has the advantage that, should the need arise, the lighting can readily be stepped up without major alterations by fitting additional tubes within an existing two-tube type.

The lighting engineer now has available the knowledge and equipment to enable him to plan a satisfactory lighting system for most of the conditions that are likely to be encountered at present. This is not, however, to claim that the best results attainable have yet been achieved in any field even under present conditions, and as new developments occur in town-planning, new problems will undoubtedly arise for the lighting engineer.

Next Month

SPECIAL REPORT

ON

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TEC223 for further information

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AP 122

INDUSTRIAL NEWS AND INFORMATION . . .

NEAGRON (Construction), Ltd., have acquired the sole rights to sell the contracting plant now on the site at Milford Haven for the contract of Christiani and Neilsen Ltd. The plant includes excavators, derricks, mobile cranes and pile driving equipment. Also for disposal is a large selection of batching machines, lifting tackle, pontoons and seagoing vessels specially constructed for the civil engineering work recently completed at Milford Haven.

Repairing Concrete

Corrosion Technical Services, Ltd., a subsidiary of John Mowlem & Co., have developed a new cement for use in repairing and bonding precast concrete. Known as Corro-Proof Ply Cement—'B' grade, the cement is compounded from an unsaturated polyester resin. The company claim that tests have shown that, when fully cured, the cement is stronger than the actual concrete. It is supplied as a two-part pack and is recommended for filling cracks in post-stressed cast concrete.

T.E.C. 45 for further details

The B-8G-2 Bull Grader

A new hydraulic bull grader, called the B-8G-2, has been announced by the International Harvester Company of Great Britain for use in conjunction with the BTD-8 crawler tractor. (This tractor was described in the August issue of *Traffic Engineering and Control*). The B-8G-2 uses the principle of direct lift, the hydraulic system being an enclosed one with pressures of 1,500 p.s.i. Assembled well within the tractor's regular heavy steel frame and radiator guard, the front mounted pump is well protected and the high working pressures of the hydraulic system permit very small diameter pistons. The pump delivery of 21 g.p.m. at rated engine speed gives a very precise blade control. The makers claim that on tests rates of excavation of 176 cubic yards per hour have been achieved with a 60 ft. push, of 142 cubic yards with a 100 ft. push.

T.E.C. 46 for further details

Hydraulic Platforms

A Grand Tour of Europe is at present being carried out by a number of Simon Hydraulic Platforms. A busy programme of demonstrations has been arranged for these machines, including visits to industrial concerns, government bodies and municipal authorities. Schedules have been arranged with the co-operation of local agents throughout Europe and the manufacturer's own representatives are travelling with the Platforms to provide fullest information.

T.E.C. 47 for further details

Conveyor with 110 ton Capacity

Numec, Ltd., are now producing a portable conveyor with a belt speed of up to 220 ft. a minute and a maximum capacity of 110 tons an hour. This is a development of their recently introduced Cadet conveyor. The elevating arms are controlled hydraulically so that a simple adjustment of the boom angle gives a range of positions, including penetration below ground level, and a reversing gear has been fitted. As with the Cadet, the 16 in. wide belt has 2 in. high corrugated sides and is fitted with 8 in. by 1½ in. cross bars at a pitch of 20 in. The power unit is a 320 c.c. petrol motor and its drive is totally enclosed in the elevating arms. Overall weight of the machine, which is known as the 'Standard', is 31 cwt.

T.E.C. 48 for further details

New Tractor Gearbox

The Ford Motor Company announces improved choice of gears, and increased power at the take-off, for a new gearbox. This gearbox is now being fitted to the Fordson Dexta. The new road speeds will be: 1st gear, .51 m.p.h. at 800 r.p.m.; 2nd gear, .92 m.p.h.; 3rd gear, 1.53 m.p.h. This gives a choice of three gears in the range up to 1½ m.p.h. at 800 r.p.m. while the original speed of 15½ m.p.h. in top at 2,000 r.p.m. is retained. The engine speed for a correct power take-off speed of 540 r.p.m. has been altered from 1,550 to 1,800 r.p.m. resulting in an increase of 3 h.p. at both engine and take-off. Belt pulley changes have been made to maintain the correct belt speed of 3,000 ft. per minute at 2,000 r.p.m.

T.E.C. 49 for further details

A 25 ft. Simon Hydraulic Platform in use.

Television in Durham

With the traffic on British roads constantly increasing in volume and velocity, the problem of traffic control in towns is growing more and more acute and reliance is placed on time operated traffic lights to control the traffic. At busy periods, it is often necessary to replace control on a time basis by the physical presence of a policeman, who controls the traffic either directly or by means of hand-operated traffic lights. The action of a police traffic-control officer depends on his being able to observe the flow of traffic, and although the system works it is not ideal.

Durham is one of many old towns with a very serious traffic problem. A river flows through the centre of the city, and not only is all through traffic constricted to pass over bridges, but is further restricted by having to pass through a small square in the city centre. In the past, the policeman on duty in the centre of this square could not observe the traffic conditions in the narrow, winding approach roads and the signals had to be operated on a time basis. However, with the installation of two closed circuit television cameras, mounted in weatherproof housings on top of 12-foot poles, the flow of traffic can now be controlled by the one man, who has a good view of approaching traffic on two monitor screens.

T.E.C. 50 for further details

One of the Pye television cameras in Durham.

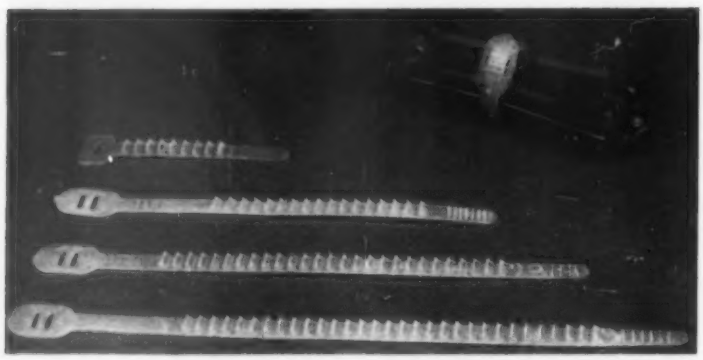
Unusual Engine Position

A new range of Bedford commercial vehicles marks a completely new approach to the design of forward control trucks. The designers have located the engine of these new Bedfords not, as is usual, in the cab, but in a separate compartment behind it, with the result that the cab, which is in front of the leading axle, has a low step, a flat, unencumbered floor, and generous room for three big men. It is cool, clean, quiet and comfortable, with the screen extending down almost to knee-level, to give drivers a close-up view of the road and additional safety. The new Bedford 'TK' range, which includes lorries, tippers and tractor units for articulated vehicles, covers five different load ratings between four tons and twelve tons. Including long and short wheelbase variants, there are seven rigid truck models, two tippers and three tractor units—a total of twelve different standard types. With all of them there is a choice of petrol or diesel engine, and with most of them there is a choice of four or five-speed gearbox and single or two-speed rear axle. This new range also have extra-thick brake drums, and a newly designed servo-assistance unit which calls for only light pedal pressure. The handbrake—a disc brake on the heavier models—is completely independent, and operates on the propeller shaft just behind the gearbox. If needed in an emergency it starts from cold, unaffected by the heat developed by the wheel brakes. Springs are longer and wider than before and the loading-line is very low, made possible by the use of 16-inch wheels.

T.E.C. 51 for further details

Berger Forms Traffic Marking Company

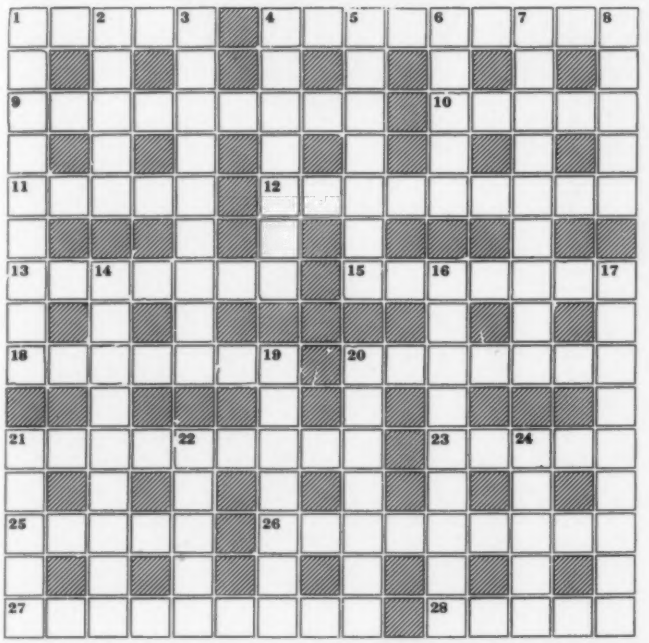
Lewis Berger & Sons, Ltd., the paint manufacturers, have announced the formation of Berger Traffic Markings Ltd., to provide a service which meets the needs of public authorities, the armed services, Government departments and other organizations concerned with road and car park marking. As well as supplying materials, Berger Traffic Markings, Ltd., sell or hire equipment which is capable of marking 3 in., 4 in. and 6 in. lines to conform with Ministry of Transport recommendations and which can be used to lay both beaded and non-beaded lines. A contracting department arranges a return of tenders and provides experienced and qualified marking crews with modern equipment. One of their main products, Cataphos paint, was promoted by the Berger Group in 1953 and is a British development of a formula which had been used in the United States for over 10 years. Berger continue the development of Cataphos in association with Sherwin Williams of America.



Plastic straps are now available in four sizes for the bundling of wires and cables. They are unperishable and simple to attach.

T.E.C. 52 for further details

TRAFFIC ENGINEERING CROSSWORD NO. 3 by YEO



Across

1 & 4. Conservative steerage? (4-4, 5)
9. Likes a walkabout. (9)
10. Totter. (5)
11. Came the dawn. (5)
12. Glue as I go. (Anag.) (9)
13. The Police? (7)
15. Some parsons can deal with this sort of thing. (7)
18. Straw? (7)
20. Insane a Chinese according to Milton. (7)
21. An orderly period. (9)
23. Sounds like Uriah Heep in flower. (5)
25. 'Wide and winding'. (5)
26. I ruled Ann. (Anag.) (9)
27. Controlled traffic. (9)
28. Sometimes fail in Scotland. (5)

Down

1. First one for the road. (4, 5)
2. A line of intersection. (5)
3. Bit of a fiddle. (4, 5)
4. Fowl ruined with debts is wicked. (7)
5. Annoyed but not necessarily by pinpricks(7)
6. An aid to reversing. (5)
7. Need of support. (9)
8. South-East Wind. (5)
14. Kind of traffic. (9)
16. Caesar did on arrival after having a look. (9)
17. Separate markings. (4, 5)
19. 'Throughout the —— world proclaim' (Mordaunt). (7)
20. The whole risked being the sound of the end. (7)
21. Restrains vertical or sloping members. (5)
22. A Goddess and a delta make another one.(5)
24. The A.C.V. Group put one up. (5)

This crossword is designed for the exercise of the skill of Highway, Municipal and Traffic Engineers and other readers, inasmuch as among the clues and their solutions will be found a number of Traffic Engineering terms which are defined in VOCABULARY OF TRAFFIC ENGINEERING TERMS published for *Traffic Engineering and Control* by Printerhall Ltd., and a copy of which is sent free to all subscribers to this journal. Since many requests are being received for it, it has been decided to make copies generally available at 2/6d. a copy, post free. The vocabulary consists of several hundred terms internationally accepted for use by traffic engineers based on definitions taken from the vocabulary prepared by the World Touring and Automobile Organization (O.T.A.) and the Permanent International Association of Road Congresses. Requests for copies should be sent, with remittance, to the Circulation Manager, Traffic Engineering and Control, 34/40 Ludgate Hill, E.C.4.

SOLUTION TO CROSSWORD NO. 2

P	E	R	E	G	R	I	N	A	T	I	O	N	■	I
E	■	E	■	E	■	N	■	M	■	■	E	■	N	
D	E	L	I	N	E	A	T	O	R	■	S	C	U	T
E	■	E	■	E	■	U	■	K	■	S	■	K	■	E
S	E	A	M	A	R	G	E	■	S	M	I	T	E	R
T	■	R	■	L	■	U	■	C	■	A	■	I	■	S
R	O	N	D	O	■	R	■	O	■	L	I	E	G	E
I	■	■	■	G	R	A	D	U	A	L	■	■	■	C
A	L	I	B	I	■	T	■	N	■	L	I	M	I	T
N	■	N	■	C	■	E	■	T	■	E	■	A	■	I
P	A	T	R	A	S	■	O	R	A	T	O	R	I	O
H	■	E	■	L	■	A	■	Y	■	T	■	T	■	N
A	R	G	O	■	I	M	M	A	T	E	R	I	A	L
S	■	E	■	■	■	M	■	I	■	R	■	N	■	E
E	■	R	E	T	R	O	G	R	E	S	S	I	N	G

Profile—concluded from page 291

Engineering has honoured Allan Baker, the first person to come through the ranks from Assistant Engineer to his present post. A unique distinction was conferred on him in 1957, with election to Honorary Membership of the Institution of Municipal Engineers, for it is highly unusual for a corporate member to be so honoured. He is an Honorary Member, too, of the Institution of Highway Engineers. In 1957 Her Majesty conferred on him the Order of a Companion of the Bath.

In spite of having had to cope with this country's expanded road programme he has given much time to work in the international field, as a member of the International Executive Committee of P.I.A.R.C., Vice-Chairman of the British Organizing Committee and Chairman of the joint OTA/PIARC/IRF Committee which has arranged this year's Study Week at Nice. At home, the task fell to him to set up a Traffic Engineering Study Group for the Institution of Civil Engineers. He has also found time to be an active member of the Road Research Board.

In his international work, Allan Baker has an important partner. His wife has attended many conferences and their Ladies' functions. Baker has proved the value of getting to know one's opposite numbers informally and socially in other countries.

Mrs. Baker has spent her married life in an atmosphere of highways and Rugby football. 'She has been properly educated,' says her husband. Willy-nilly, she has had to be interested in traffic problems too, if she was to have more than the minimum of her husband's company. 'This job could divorce you,' says Baker. Luckily, it has not, and he can take pleasure in his two small grandsons, who are 'great fun'. As they are, respectively, four and one year old their future is not yet decided. Some day, though, their grandfather may present them with two of his most treasured possessions—a photograph of the opening of M1, and the small silver shield their great-grandfather won for taking all ten wickets against a local side the year their grandfather was born.

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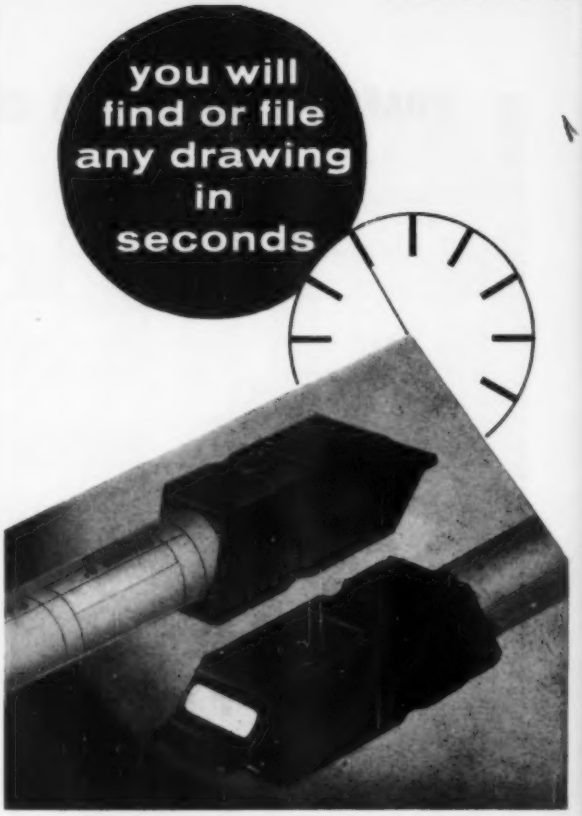

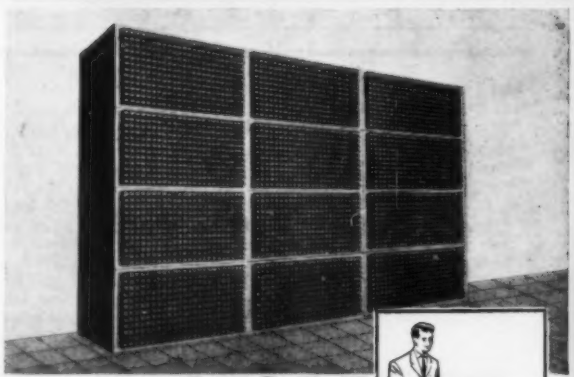

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